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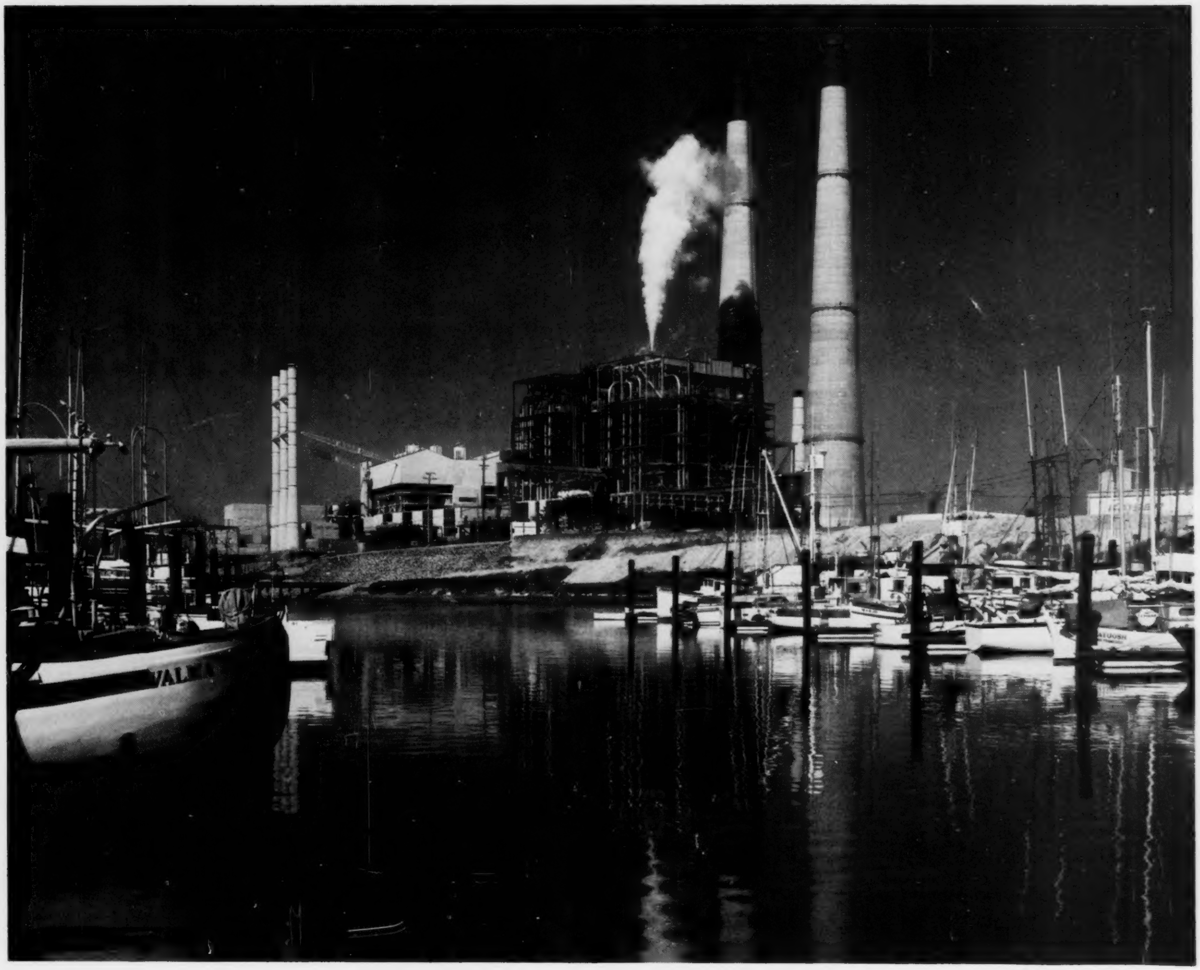

Fishes and Power Plants

Marine Fisheries Review

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Moss Landing Power Plant. (Photo courtesy of Pacific Gas and Electric Company.) See article beginning on page 7.

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MFR PAPER 1265

The Cuban Grouper and Snapper Fishery in the Gulf of Mexico

JOSEPH E. TASHIRO and SUSAN E. COLEMAN

ABSTRACT—The history and development of the Cuban grouper and snapper fishing in the Gulf of Mexico are reviewed. Included is information concerning fishing grounds, catch composition, fishing fleet, and operations and catches. The implications of extended fisheries jurisdictions for Cuba are briefly discussed.

INTRODUCTION

This paper reviews the development of the Cuban grouper and snapper fishery in the Gulf of Mexico. Starting as a handline fishery from sailing vessels, the fishery developed into the present bottom longline operation. The activities of the Cuban State Flota del Golfo (Gulf Fleet) organized under Fidel Castro in 1963 are emphasized.

Very little information is available in U.S. publications concerning the Gulf Fleet. The information for this paper was compiled mainly from Cuban fishery publications and from unpublished reports by the National Marine Fisheries Service (NMFS) Law Enforcement and Marine Mammal Protection Division, Southeast Region.

HISTORY OF THE FISHERY

Cuban vessels of various types have fished waters off Mexico and Florida for mullet, groupers, snappers, and other fishes since Spanish colonial times (Martinez, 1948; Leal, 1971).

In 1850, sailing vessels known as "viveros"—fishing vessels with live-wells to hold and transport live catches—began fishing off Florida and Mexico. Groupers and other reef fishes were caught by handlines and placed in the live-wells. When the wells were filled, the viveros returned to Havana, Cuba, where the live catch was marketed (Anonymous, 1966).

In the ensuing years the fleet became informally known as the "Flota del Alto" (Deep Water Fishing Fleet) and was affiliated with a cooperative established in 1946 and located on Havana Bay (Martinez, 1948; Buesa, 1964). Gradually, viveros were converted to "neveros"—vessels in which the catch is iced. In 1955, the Deep Water Fishing Fleet had 68 sailing vessels from 80 to over 100 feet (24.3-30.5 m) in length, many with auxiliary power (Suarez Caabro, 1957). In the late 1950's, about 40 of these vessels, averaging over 45 years of age, were still used for fishing. The entire Cuban fishing fleet consisted of 2,500-3,000 principally small nonmotorized coastal boats. In 1959 the Cuban government began to nationalize and organize this artisanal fishing industry. The main thrust was toward the development of Cuban coastal, nearby Caribbean, and Gulf of Mexico fisheries (Kravanja, 1972). A ship-building program began in 1961 to replace the existing fishing fleet with new, powered, wooden vessels of about 10 standard classes and designs (Abascal, 1966). In 1963, a centralized state fishing administration, the "Instituto Nacional de la Pesca, INP" (National Fishing Institute), was established to coordinate activities and modernize the industry. The INP finances, manages, and directs its fishing, seafood processing, distribution, marketing, seaport, and shipbuilding enterprises. It also fixes production goals, determines salaries, and establishes prices. Other widespread activities include political and social programs which include education, training, and housing for INP personnel.

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THE CUBAN GULF FLEET

General

The Cuban Gulf Fleet was organized by the INP in 1963 and began operations in 1964. The Gulf Fleet size increased from 65 vessels in 1963 (Abascal, 1966) to about 140 vessels of various designs and sizes in 1967 (Young, 1971). Apparently, the fleet overexpanded and the desired level of proficiency still was not attained. As the INP fishing policy evolved, emphasis shifted from the Gulf Fleet to distant water, more productive or more valuable fisheries (Kravanja, 1972). After 1967, the Gulf Fleet size decreased (Fig. 1) when many of the older and smaller vessels were placed in Cuban coastal fleets, and 65 of the largest vessels were converted into shrimp trawlers (Chang, 1971). By

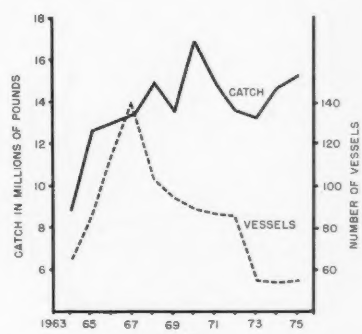


Figure 1.—The Cuban Gulf Fleet grouper and snapper catch and number of vessels, 1964-75. Sources: Compiled from *Mar y Pesca*, 1965-75; Carles Martín and Liubimova, 1967; Young 1971.

1975, the Gulf Fleet, though smaller, was an effective fishing force of 55 standardized vessels (Ubeda, 1975).

Grounds

The fishing grounds are on shelf areas off the west coast of Florida and off the north coast of the Yucatan Peninsula (Fig. 2). The Gulf Fleet fishes primarily in depths of 8-44 fm (15-81 m) (Carles Martín and Liubimova, 1967) favoring the shallower depths to 30 fm (55 m). Off Florida, the grounds extend from the Dry Tortugas to Cape San Blas and Cuban vessels usually fish 20-80 nautical miles (37-146 km) offshore (Fuss, 1972, and unpublished reports[1]). Off Mexico, the grounds are from 12-100 nautical miles (22-185 km) offshore. The INP conducted a comprehensive resource, biology, and oceanography survey of the Campeche Shelf grounds. The published results appear in Instituto Nacionale de la Pesca, Centro de Investigaciones Pesqueras — INP/CIP (1974, 1975).

Species Sought

The Cuban fishing effort is directed toward the "cherna americana" or red grouper (*Epinephelus morio*), which constitutes about 90 percent of the total catch (Abascal, 1968). The average size of a fish is about 10 pounds (4.5 kg), although fish over 17 pounds (7.7 kg) are sometimes caught. The remainder of the catch is composed mainly of other groupers, snappers, king and Spanish mackerels, grunts, sharks, and porgies (Table 1).

Gear

Although the traditional handline is still used to some degree, the "palangre de fondo," bottom longline (Fig. 3) came into general use about 1965 and is the principal fishing gear (Cubillas, 1965). The bottom longline is 3,280-4,921 feet (1,000-1,500 m) in length, buoyed at each end and weighted in between to keep the longline near the bottom. As many as 250-300 branch lines, each with a baited hook, are spaced about 10-20 feet (3-6 m) apart on the fishing portion of the longline. The bottom longline is set and retrieved

[1]C.M. Fuss, Jr., Chief, Law Enforcement and Marine Mammal Protection Division, Southeast Region, National Marine Fisheries Service, NOAA, St. Petersburg, FL 33702. Unpublished reports, 1972-76.

Figure 2.—The Cuban Gulf Fleet vessels have been observed within the shaded area off west Florida. The Campeche Shelf fishing area is also shaded. Sources: Law Enforcement and Marine Mammal Protection Division, NMFS, NOAA, St. Petersburg, FL 33702; Monthly Report of Foreign Fishing Activities off the Southern U.S. Coast (and other unpublished reports), 1972-76. Carles Martín and Liubimova, 1967; Zupanovic and González, 1975.

Table 1.—List of fishes commonly landed by the Cuban Gulf Fleet[1].

	Common name[2]	
Scientific name[2]	United States	Cuba
Squaliformes	Sharks	Tiburones
Serranidae		
Epinephelus adscensionis	Rock hind	Cabra mora
E. itajara	Jewfish	Guasa
E. morio[3]	Red grouper	Cherna americana
Mycteroperca bonaci	Black grouper	Aguaji; Bonaci
M. interstitialis	Yellowmouth grouper	Abadejo
Mycteroperca spp. and *Epinephelus* spp.	Groupers	Chernas; Meros
Lutjanidae		
Lutjanus analis	Mutton snapper	Pargo criollo
L. campechanus	Red snapper	Pargo colorado; Guachinango
L. griseus	Gray snapper	Caballerote
L. synagris	Lane snapper	Biajaiba
L. vivanus	Silk Snapper	Pargo de lo alto
Ocyurus chrysurus	Yellowtail snapper	Rabirrubia
Rhomboplites aurorubens	Vermilion snapper	Cagon; Cotorro
Lutjanus spp.	Snappers	Pargos
Pomadasyidae		
Haemulon aurolineatum	Tomtate	Jeníguano
Haemulon spp.	Grunts	Roncos
Sparidae	Porgies	Bajonado; Pez de pluma
Scombridae		
Scomberomorus cavalla	King mackerel	Sierra
S. maculatus	Spanish mackerel	Serrucho
S. regalis	Cero	Pintada; Pintadilla

[1]Only species identified in literature are included.
[2]Common and scientific names follow Bailey et al. (1970). Cuban common names are from *Mar y Pesca* and other sources.
[3]*Epinephelus morio* is the target species.

manually from a fiberglass launch (Sáez, 1973). Scaled sardines and shark and grouper entrails are often used as bait (Chang, 1971).

Vessels and Personnel

In recent years, the Gulf Fleet was composed mainly of "Lambdas," 75-foot (23-m) diesel-powered, wooden-hulled vessels, capable of speeds of about 10 knots (Fig. 4). The fish hold capacity is about 33 tons (30 t). Each Lambda has a complement of 11-20 men; there were 1,082 men in the Gulf Fleet in 1975 (Young, 1971; Ubeda, 1975). Most of the crew are trainees and students between 16 and 25 years of age. An important function of the Gulf Fleet is the training of fishermen, technicians, and officers for service in INP fishing enterprises (Young, 1971; Sáez, 1973).

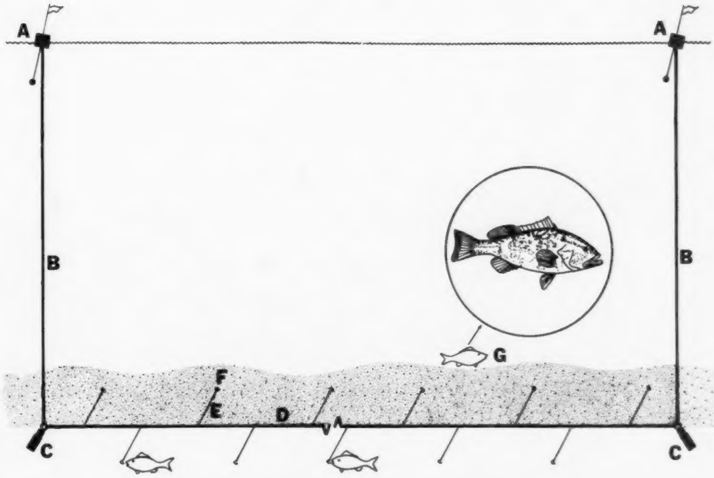


Figure 3.—Cuban Gulf Fleet: Diagram of a typical bottom longline for groupers and snappers. A. marker buoy, B. buoy line, C. drag weight, D. mainline, E. branch line, F. bait and hook, G. target fish, the red grouper. Sources: Law Enforcement and Marine Mammal Protection Division, NMFS, NOAA, St. Petersburg, FL. 33702; Sáez, 1973.

Fishing and Fishing Operations

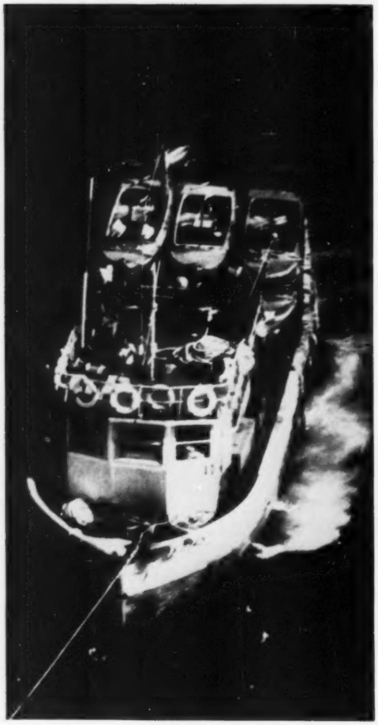
The operations of the Gulf Fleet are directed and coordinated by INP from "El Puerto Pesquero de La Habana" (The Fishing Port of Havana). The vessels are directed to fishing grounds on the Campeche Shelf or the West Florida Shelf and communications are maintained with the INP fishing headquarters during the trip.

Each Lambda serves as a mother vessel and usually has six 16-foot (5-m) fiberglass longlining launches on board. Upon arrival at the fishing grounds, the launches are placed in the water. The two-man crew makes an initial set of the bottom longline gear; thereafter, the longline remains in the water until the end of the fishing day. The launch progresses along the mainline while the crew retrieves the catch and simultaneously baits and resets the mainline, one hook at a time. The mainline is traversed in this manner usually from six to eight times per day. The catch is transferred to the Lambda when the crew returns for lunch and at the end of the fishing day (Arango, 1974). While the launches are fishing, the Lambda crew may scout for fishing areas or fish with handlines, but the vessel usually remains within 2 nautical miles (3.7 km) of the launches (Sáez, 1973). The launches are loaded aboard the mother vessel at the end of the day.

Figure 4.—The 75-foot (23-m) Lambda is the principal vessel used by the Cuban Gulf Fleet. Longlining launches can be seen stacked on the after deck. Photograph courtesy of the Law Enforcement and Marine Mammal Protection Division, NMFS, NOAA, St. Petersburg, FL 33702.

The fishing trip cycle is about 40 days: 10 days in port, 27 days fishing, and 3 days in transit (Instituto Nacional de la Pesca Cuba — INP, 1967). Each vessel averages nine trips annually; the fleet averages 450 vessel-trips (Chang, 1971).

Traditionally, Cuban vessels operated independently, but beginning about 1971, the Gulf Fleet was organized into 13 flotillas of from two to four Lambdas each. A vessel captain is selected as commander of each flotilla. Two operational systems are used by the flotillas: the "En compaña" (in company or group) and "Enviada" (envoy or transport).



The 75-foot (23-m) Lambda (above) is the principal vessel used by the Cuban Gulf Fleet. The FG on the stack stands for Flota del Golfo. At left is a 66-foot (20-m) Gulf Fleet vessel. Longlining launches can be seen stacked on the after deck of the 75-foot Lambda below. Photos are from the Law Enforcement and Marine Mammal Protection Division, Southeast Region, National Marine Fisheries Service, NOAA.

In the compaña system, a Lambda from a flotilla is designated to take the flotilla's catch to Cuba after the first half of the trip, while the remainder of the flotilla continues fishing. The catch is unloaded at the Fishing Port of Havana, then the vessel returns to the fishing grounds with supplies, ice, and fuel, and resumes fishing. The flotilla returns to Cuba after 24-30 days at sea.

In the enviada system, specialized transport vessels go to fishing grounds and transship a flotilla's catch to port but do not engage in catching fish (Chang, 1971).

In the grouper-snapper fishery where the resource is dispersed and fish are landed individually by manual labor, the catch per unit of effort is low in comparison to other fisheries where the resources are concentrated and harvested by nets.

Fishing efficiency has increased greatly, however, since the Gulf Fleet

began operations in 1964. Port and shipyard facilities were improved. The fleet was standardized from an assortment of vessels to the Lambda-class almost exclusively. All vessels have electronic fish-finding, navigation, and communication equipment. Each Lambda has a hydraulic crane for loading and unloading of the longline launches during fishing operations (Abascal, 1968). The new diesel-powered, fiberglass launches are lighter, more maneuverable, and have twice the payload capacity of the former wooden launches. The fishing power of the longlines was increased from 100 hooks (Abascal, 1966) to 250-300 hooks (Arango, 1974).

Effective fishing time was increased when vessels began fishing as organized flotillas with supply and transport vessels (Chang, 1971). Although valid catch comparisons cannot be made betweeen vessels because of size, gear, and fishing effort variations, the catch-per-vessel-per-year increased from 96,000 to 277,000 pounds (44-126 t) from 1967-75 (Fig. 5).

The Gulf Fleet is experimenting to further increase efficiency by extending the duration of trips, rotating the fishermen from shore to vessels to shore, and mechanizing the longline operation (Ubeda, 1975).

CATCH INFORMATION

Catch information is not readily available to us. We have no access to data for the Deep Water Fishing Fleet during 1959-63. Catch information for the Gulf Fleet from 1964 to 1974 was compiled from various sources and often represents estimates based on seasonal catches, analysis of interviews with fishermen, and observations of fishing activities by NMFS.

The total Gulf Fleet catch increased from 8.8 million pounds (3,986 t) in 1964 to 15 million pounds (6,800 t) in 1968 (Table 2). The average annual catch from 1967 to 1975 was 14.5 million pounds (6,577 t), with a low of 13.3 million pounds (6,050 t) in 1973 and a high of 17 million pounds (7,700 t) in 1970. Catches for 1967, 1969, 1972, and 1973 were below the annual mean, but catches increased above the annual mean in 1974-75. At U.S. prices, the value of the 1975 catch of 15.3 million pounds (6,927 t) is 6.1 million dollars. The Campeche Shelf produces about 71 percent of the Gulf Fleet catch; the remainder is from the West Florida Shelf. From 1971 to 1975, the annual catch varied from 8.4 to 11.2 million pounds (3,800 to 5,073 t) for the Campeche Shelf and from 3.5 to 4.9 million pounds (1,597 to 2,214 t) for the West Florida Shelf.

Mexico and the United States also fish on the Campeche Shelf. Mexico generally fishes for groupers closer to shore than the United States or Cuba. In the Gulf of Mexico in 1972, for example, Mexico landed 38.8 million pounds (17,600 t) of groupers and snappers primarily from the Campeche Shelf (Food and Agricultural Organization, 1974). U.S. vessels fish mainly for snappers in deeper waters of 60-140 fm (110-256 m). The Campeche Shelf was an important fishing area for the U.S. snapper fleet, but in recent years, activities have decreased. Catches dropped from about 8.1 million pounds (3,674 t) in 1964 (Allen and Tashiro, 1976) to an annual average of less than 0.7 million pounds (318 t) from 1973 to 1975.

The Gulf Fleet competes with U.S. snapper and grouper vessels on the West Florida Shelf. In 1970, the Law Enforcement and Marine Mammal Protection Division of NMFS, in cooperation with the U.S. Coast Guard, began surveillance of foreign fishing activities in the Gulf of Mexico. From their observations and from interviews with Cuban fishermen, they estimated the catch-per-trip for each Lambda at from 30,000 to 50,000 pounds (13,608-22,680 kg).

For the West Florida Shelf, the annual Cuban Gulf Fleet catch from 1971

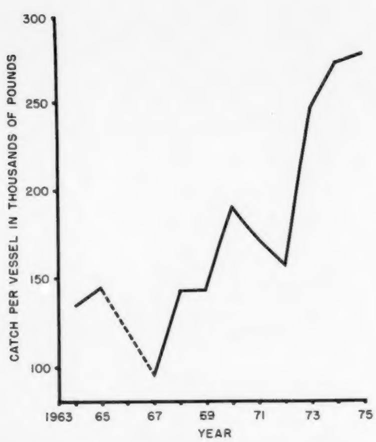


Figure 5.—The Cuban Gulf Fleet grouper and snapper catch per vessel, 1964-75. Sources: *Mar y Pesca*, 1965-75; Carles Martín and Liubimova, 1967; Young 1971, and Table 2.

Table 2.—Grouper and snapper catches[1] from the West Florida Shelf and the Campeche Shelf by the Cuban Gulf Fleet, 1964-75. Catch figures are in thousand pounds and metric tons (in parentheses).

Year	West Florida Shelf	Campeche Shelf	Total
1964	[2]0	[3]8,787 (3,986)	8,787 (3,986)
1965	[2]0	[3]12,566 (5,700)	12,566 (5,700)
1966	[4]—	—	—
1967	—	—	[5]13,448 (6,100)
1968	—	—	[5]14,991 (6,800)
1969	—	—	[5]13,669 (6,200)
1970	—	—	[5]16,975 (7,700)
1971	[6]3,960 (1,796)	[7]11,031 (5,004)	[5]14,991 (6,800)
1972	[6]3,780 (1,714)	[7]9,904 (4,494)	[8]13,684 (6,208)
1973	[6]4,960 (2,250)	[7]8,377 (3,800)	[9]13,337 (6,050)
1974	[6]3,520 (1,597)	[7]11,185 (5,073)	[10]14,705 (6,670)
1975	[6]4,880 (2,214)	[7]10,392 (4,714)	[11]15,272 (6,928)

[1]Other species groups may comprise up to 10 percent of the catch.
[2]Apparently no fishing 1964-65.
[3]Estimated from Carles Martín and Liubimova, 1967.
[4]Indicates data not available.
[5]Morales, 1972.
[6]Estimated by C.M. Fuss, Jr., Chief, Law Enforcement and Marine Mammal Protection Division, Southeast Region, NMFS, NOAA, St. Petersburg, FL 33702.
[7]Estimated by the authors.
[8]Estimated from the annual grouper catch reported in Sáez, 1973.
[9]Estimated from 8 months data reported in *Mar y Pesca* for 1973.
[10]*Mar y Pesca*, 1975, Numero Especial.
[11]Estimated from 8 months data in Ubeda, 1975.

to 1975 was conservatively estimated to average 4.2 million pounds (1,905 t) (see footnote 1). The U.S. catch for the same area in 1974 was 13 million pounds (5,897 t) of snappers and groupers (Snell, 1976).

DISCUSSION

The Cuban grouper and snapper fishery, following a period of organization and development, emerged as the present successful Gulf Fleet. Fleet size and catches in recent years were fairly stable. With the present fishing methods, fishing proficiency is approaching its maximum limits. Catches will not increase appreciably without additional fishing effort, which in this case, means more vessels and personnel. The INP fishery administrators are aware of the productive limitations of this fishery; but in assessing the importance of the Gulf Fleet to Cuba, the INP considers not only quantity of the catch but also other aspects such as social welfare, employment, training, and national prestige.

Gulf Fleet catches of groupers and snappers are not exported. These fish are a traditional and popular food item and are an important protein source for Cuban domestic consumption (Cubillas, 1965; Instituto Nacional de la Pesca Cuba-INP, 1967). From 1964 to 1967 the INP changed much of its "Caribbean first" fishing policy and concentrated effort on the development of more productive, distant-water, or high dollar value fisheries. Spiny lobster, shrimp, and tuna ranked highest in value as fishery exports. As a result of this policy change, Gulf Fleet size decreased and many bottom longline vessels were converted and transferred to other fisheries. The Gulf Fleet, however, has been able to maintain catch levels with fewer vessels by increasing fishing efficiency.

Gulf Fleet catches are made in waters that are now under the jurisdictions of Mexico or the United States. That Cuba wishes to continue Gulf Fleet operations is reflected in her ready recognition of Mexico's Exclusive Economic Zone (EEZ) and the subsequent fishery agreement with that country. On 31 July 1976, Mexico unilaterally extended her EEZ to 200 nautical miles (371 km) off shore; within this zone is the Campeche Shelf. A bilateral fisheries agreement between Cuba and Mexico was ratified in July 1976, permitting Cuba to continue fishing off Mexico until at least 1980. The Cuban quota for groupers and red snapper caught within the EEZ was set at 22 million pounds (10,000 t).[2]

This allotment exceeds the estimated mean annual catch of the Gulf Fleet from the Gulf of Mexico of 14.5 million pounds (6,577 t). If the Gulf Fleet extends its operating range, additional fishing grounds would be available on the Campeche Shelf west of the Yucatan Peninsula and in the Caribbean Sea.

The United States also created a Fishery Conservation Zone (FCZ) extending 200 nautical miles (371 km) off shore; within this zone is the West Florida Shelf. According to the provisions of the Fishery Conservation and Management Act of 1976, all foreign countries will be prohibited from fishing within the FCZ after 1 March 1977 without a U.S. fishing permit. This would decrease the Cuban catch by about 4.2 million pounds (1,905 t) annually unless Cuba recognizes the FCZ and negotiates a fishery agreement with the United States.

ACKNOWLEDGMENT

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MFR PAPER 1266

Entrapment and Impingement of Fishes by Power Plant Cooling-Water Intakes: An Overview

CHARLES H. HANSON, JAMES R. WHITE, and HIRAM W. LI

ABSTRACT–An overview of the recent information available on fish entrapment and impingement by power plant cooling-water intakes is presented. The types of biological problems caused by intake structures, the strengths and weaknesses of various water intake/fish protection systems, and the biological/ecological processes relevant to this problem are discussed. Factors contributing to direct and delayed mortality in screen-impinged fish are examined with emphasis on the relationship between water velocity, impingement time, and physiological stress. In considering the present state of developing impact assessments we have pointed out areas which need refinement, omissions, and limitations of our present knowledge. The biological impact of water withdrawal for power plant cooling can be minimized by consideration of intake siting and design criteria including site evaluations, cooling system design (i.e., closed-cycle cooling or once-through cooling system), and the use of guidance, diversion, and fish salvage systems. We conclude that future research should focus on examining basic behavioral and physiological mechanisms associated with fish entrapment and impingement in combination with ecological processes of those populations and communities influenced by proposed and existing projects.

INTRODUCTION

Despite pleas for energy conservation, the demand for new electrical generating plants has continued to increase. This rapid growth in generating capacity will continue to place new demands on the nation's water resources to provide cooling water needed for steam condensation. Entrainment,[1,2] entrapment,[3] and impingement[4] of fish and other aquatic organisms by water intake structures and the discharge of thermal and chemical effluents create potentially serious environmental problems.

Aroused public concern for the conservation of natural resources is reflected in the enactment of the Federal Water Pollution Control Act of 1972 (Public Law 92-500). This act emphasizes the need to minimize thermal effects associated with discharges from power plant cooling systems (Section 316a) and the need to minimize entrainment, entrapment, and impingement of aquatic biota by cooling-water intake structures (Section 316b). Section 316b of Public Law 92-500 requires that each intake system reflect the best available design and technology for minimizing deleterious effects on aquatic life and assuring continued balance of aquatic ecosystems. However, no clear guidance or criteria are available to date for determining whether an adverse environmental impact has occurred. The environmental consequences of such losses, whether from entrainment or impingement, can be evaluated only in the context of the effect on the ecological balance of the aquatic community.

The purpose of this review is to describe the types of problems caused by intake structures, to assess the strengths and weaknesses of various water intake/fish protection systems, to summarize the extent of our understanding of biological processes relevant to this problem, and to propose the direction for future research which will lead to the design of better intake structures.

OVERVIEW OF THE PROBLEM

Population growth and the shift of our culture towards energy-intensive activities will combine to increase the demand for energy in the decades ahead. A concomittant increase in the demand for cooling water is inevitable. To characterize the magnitude of this demand, consider that conventional 1,000 MWe (megawatts electrical) fossil fuel and nuclear power plants require cooling water at a rate of approximately 50 and 75 m^3/s, respectively. This demand is currently being met by diverting natural surface waters which also serve as habitat for a diverse aquatic flora and fauna.

The use of natural surface waters for thermal dissipation from steam electric generating stations imposes two major potential sources of damage on aquatic organisms: thermal discharges and mortality at cooling-water intakes. Effects of the thermal component of power plant effluent have been extensively studied and widely publicized. However, the potentially adverse impact on aquatic organisms resulting from entrainment, entrapment, and impingement by cooling-water intake systems went largely unnoticed until the early 1970's. Expanded awareness of the magnitude of intake related problems has precipitated an intensive effort by regulatory agencies, power utilities, and environmental consultants to document the problem, arrive at rational decisions regarding the consequences of these losses, and formulate

[1] An organism which is drawn into a water intake as part of the volume which it occupies is said to be entrained.
[2] For information on entrainment, see reviews by Beck and Miller (1974) and Marcy (1975).
[3] Entrapment refers to the physical blocking of larger entrained organisms by a barrier, generally some type of screen located within the intake structure.
[4] Impingement occurs when the entrapped organism is held in contact with the barrier.

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acceptable solutions for minimizing adverse environmental effects.

Power plants having cooling system intakes which impinge excessive numbers of fish may be required to implement closed-cycle (recirculating) cooling systems, thus reducing the required cooling-water volume and decreasing the intake approach velocity which should result in lower impingement mortality. Closed-cycle cooling has been proposed as the best available technology for minimizing the adverse impact of cooling-water intake structures on fisheries resources and aquatic ecosystems (Anonymous[5]). Closed-cycle cooling, however, is expensive to install in existing plants and may not, in all cases, represent the most efficient design for a particular site. In cases where entrainment or impingement mortality is considered excessive, all potential alternative methods should be considered.

A major conflict exists, however, in evaluating the significance of fish losses resulting from impingement and arriving at rational criteria for establishing the level of intake damage which is legally "acceptable." For example, one power station located on a river in the midwest United States impinges an estimated 100,000 fish per year. A Gulf coast station, on the other hand, impinges an estimated 20 million fish per year. In each case, impinged fish ranged from 40 to 100 mm in length and represented juvenile life stages. What is the potential impact on the aquatic ecosystem resulting from the loss of these fish? Clearly each must be viewed as a separate case, unique in terms of the species involved, the characteristics of the receiving water ecosystems, and the potential impact.

IMPINGEMENT DAMAGE

Conventional intake systems rely on screens to prevent the entry of debris and large fish, but these systems do not completely prevent the passage of small fish. In addition, it is difficult to predict the magnitude of entrainment and entrapment by various intake designs, especially in power plants sited in estuaries which serve as nursery areas for anadromous and marine species. Entrapment and impingement of juvenile and adult fish may result in immediate death due to mechanical abrasion and suffocation. Exposure to stress conditions which does not result in immediate death may lead to eventual mortality of the organism due to a lowered resistance to predation and disease or an inability to actively compete for food. Severity of the loss of juvenile fish may not be noticeable for some time since mean generation time for many species is measured in years. By this time changes in the population dynamics and structure may be substantial and irreversible.

The magnitude of entrapment-impingement losses at several power plant intakes seems significant (Table 1), but the biological importance of such losses is unknown. During recent years the trend has been to simply document the occurrence of fish loss. This, however, provides little insight into the mechanisms or factors which influence entrapment-impingement, nor is it very helpful when attempts are made to improve intake designs.

Historically, intake design criteria have been developed on a trial-and-error basis. It is apparent from Table 1 that this technique has resulted in limited success. Some intake designs have functioned well; however, extrapolations from one site to another frequently yield unacceptable results. It is obvious that no one has understood why a particular design worked at one site and not at another. Existing criteria lack generality and precision because studies leading to an understanding of basic mechanisms were not made.

Initial attempts to improve general guidelines for developing intake design criteria were based on evaluating fish performance capabilities. Fish performance is determined by using forced swimming trials and time to fatigue for fish exposed to velocities in respirometers or stamina tunnels. In general, these fish are confined within an experimental apparatus in which velocity preferences cannot be tested. As a result of performance studies it is generally recommended that large intake areas should be provided to reduce intake velocities. That swimming capability cannot be considered independent of behavioral response is illustrated by extensive fish losses at plants with low intake velocities.

The damage incurred by fish at water intakes depends on the species, the stage of life history, and size. Survival of fish encountering an intake is in part a function of preimpingement excitement and stress. Chittenden (1973) observed the variability of the effects of handling on American shad, *Alosa sapidissima,* concluding that the intensity of excitement determined whether the fish lives, dies immediately, or dies later. Several investigators reported delayed mortality of fish following periods of hyperactivity and the associated lactic acid accumulation in the blood (Black, 1958; Beamish, 1966; Chittenden, 1973). Lactic acid, the end product of the biochemical pathway

[5]Anonymous. 1975. Guidelines to determine best available technology for the location, design, construction, and capacity of cooling water intake structures for minimizing adverse enviromental impact. Section 316(b) P.L. 92-500. U.S. Environ. Prot. Agency. Unpubl. Manuscr., 69 p.

Table 1.—Estimated entrapment-impingement losses at several power plant cooling-water intakes.

Plant	Location	Study duration	No. of fish	Reference
Allen Steam Station	Lake Wylie	Oct. 1973-Sept. 1974	898,913	Edwards et al. (1976)
Oconee Nuclear Station	Lake Keowee	July 1974-May 1975	1,064,262	Edwards et al. (1976)
Marshall Steam Station	Lake Norman	Apr. 1974-Mar. 1975	3,769,300	Edwards et al. (1976)
Buck Steam Station	Yadkin R.	July 1974-June 1975	4,069	Edwards et al. (1976)
Palisades Nuclear Power Plant	Lake Michigan	July 1972-June 1973	584,687	Edsall (1975)
Waukegan Generating Station	Lake Michigan	June 1972-June 1973	1,200,000	Edsall (1975)
Nine Mile Point	Lake Ontario	Jan.-Dec. 1973	5,000,000	Edsall (1975)
Zion Plant	Lake Michigan	Sept.-Dec. 1973 Mar.-June 1974	929,000	Edsall (1975)
Quad Cities Plant	Mississippi R.	Jan.-Dec. 1974	10-14,000,000	Truchan (1975)[1]
Muddy Run Pumped Storage Generating Plant	Susquehanna R.	June-July 1970	[2]56,600,000	Snyder (1975)

[1]Truchen, J. G. 1975. Guidelines to determine best available technology for the location, design, construction, and capacity of cooling water intake structures for minimizing adverse environmental impact, Sec. 316(b) P.L. 92-500. Unpubl. manuscr., 69 p. U.S. Environ. Prot. Agency.
[2]Entrainment and subsequent passage of juvenile fishes.

(glycolysis) which meets energy demands of muscle tissue during anaerobic metabolism, accumulates in the circulatory system during periods of excitement or intense swimming effort. Energy demands of swimming during entrainment or entrapment result in increased concentration of lactic acid in the tissues causing muscle fatigue and suffocation (Dominy, 1971). Probable causes of delayed mortality following preimpingement excitement include acidosis and inadequate oxygenation of blood due to the Bohr effect.

Fish impinged on power plant intake screens are killed outright or may suffer delayed mortality due to exhaustion, suffocation, or external or internal injury. The extent of physical damage is directly related to the duration of impingement, techniques of handling impinged fish, and the intake water velocities. Pressure due to the latter hinders respiration, especially critical for fish fatigued prior to impingement. Factors contributing to delayed mortality in screen-impinged fish have been examined exclusively in short-term survival studies. Very little information exists on indirect delayed mortality in impinged fish as a result of increased susceptibility to disease or predation for those fish which successfully bypass the diversion and are returned to the receiving waters.

Since the species and life history stages of fish differ from one geographical region to another it is not surprising that impingement mortality varies greatly from one site to another. For example, juvenile menhaden, blueback herring, striped bass, alewives, and shad appear to be particularly vulnerable to impingement. Catfish, carp, and many salmonids, on the other hand, appear to be relatively less sensitive to impingement stresses. Furthermore, it has been shown (Prentice and Ossiander, 1974; Skinner, 1974) that as fish size increases, mortality resulting from impingement decreases.

The relationship between water velocity and impingement time on physiological stress and survival has been examined by Prentice and Ossiander (1974). In general, the degree of oxygen stress observed in juvenile salmon increased with both increasing water velocity and increasing impingement time. For example, oxygen stress and a loss of equilibrium were evident in fish impinged 15 min at a water velocity of 61 cm/s. Reduced activity was evident in fishes 48 h after impingement of 9 min or longer at a velocity of 61 cm/s. As might be expected, survival decreased as the duration of impingement and water velocity increased.

Prentice and Ossiander (1974) reported internal hemorrhaging in impinged salmonids and found the minimal velocity at which hemorrhaging occurred was approximately 46 cm/s. At 61 cm/s hemorrhaging occurred in approximately 10 percent of the fish tested after a 30-s impingement, increasing to 33 percent after impingement for 60 s. Bell (1974) observed internal hemorrhaging, eye loss, and bent gill opercula in fish as a result of impingement. Impingement may also result in fish being partially descaled. Loss of scales destroys the integrity of the protective body covering causing disruption of essential osmotic differentiation between fish body fluids and their environment and increasing susceptibility to disease and parasitism. Clupeids, which have deciduous scales, are particularly vulnerable to descaling. Mortality among this group as a result of impingement and mechanical damage has been high.

Smith et al.[6] found the injury rate resulting from scale loss was inversely proportional to fish size (i.e., small fish are affected greatly by scale loss). They reported that delayed mortality following partial descaling was a significant problem; studying salmon (*Oncorhynchus* spp.) less than 30 cm in length, death occurred 3-18 h after 30-50 percent scale loss. In addition, fish behavior after scale loss was observed to change markedly. One hour after descaling, juvenile salmon were noticeably less active and less alert to visual stimuli than were controls. Loss of equilibrium occurred approximately 3 h after descaling, followed by a decrease in respiration and activity. In general, death occurred approximately 4 h after descaling. The time sequence varied with the severity of scale loss. Loss of body weight followed descaling in marine species, presumably as the result of osmotic removal of water and body fluid through the injured skin surface and the gills. Delayed mortality resulting from scale loss may arise from an osmotic imbalance and an increased susceptibility to infection and disease. In addition, physiological stress due to scale loss may substantially decrease the ability of a fish to avoid predators.

Mortality resulting from mechanical abrasion may increase in areas characterized by high silt and debris loading. High debris densities and algal mats have been reported to trap and impinge fish on intake screens.

Accumulation of debris on trash racks and intake screens not only serves to entrap and entangle fish, resulting in increased mechanical damage, but also effectively alters the hydraulic flow field and approach velocities associated with each intake structure. High concentrations of suspended sediment abrade the eyes, gills, and epidermal tissue of impinged fish. Environmental factors such as suspended sediments and debris loading may significantly reduce the effectiveness of an otherwise acceptable cooling-water intake.

From the literature it appears that mechanical damage may be a significant factor in survival of entrapped and impinged organisms. However, data are insufficient to evaluate the conflicting nature of many of the findings. Refinement in sampling methodologies is a prerequisite for accurately determining the importance of mechanical abrasion as a source of biological damage.

IMPACT ASSESSMENT

Predicting the magnitude of fish loss resulting from entrapment and impingement by cooling system intakes is a major challenge. Estimating the population and community response to intake related mortality of either a proposed or existing power plant is extremely complex. Mathematical

[6]Smith, L. S., J. B. Saddler, R. D. Cardwell, A. J. Mearns, H. M. Miles, and G. T. Sakagawa. 1969. Some physiological changes in juvenile Pacific salmon after capture and tagging. Fish. Res. Inst., Coll. Fish., Univ. Wash. Rep., Seattle, Wash. Unpubl. manuscr., 29 p.

models of population dynamics have been utilized to evaluate the potential impact of a project on the aquatic ecosystem. Model simulations typically include estimates of species diversity and abundance, the ecological role of susceptible species and their reproductive strategies, and the location and design of the power plant and its condenser cooling-water system.

Model simulations to date, however, have been hindered by inadequate information regarding entrapment and impingement mortality and the population dynamics of those organisms inhabiting the area. This lack of information—particularly on natural mortality levels, age specific fecundity rates, immigration and emigration, recruitment into the population from surrounding areas as well as recruitment from one age class to another within a population—has forced model simulations to rely on unsubstantiated assumptions or estimates. The problems of predictive modeling are compounded by the intake of larval and juvenile fish which pose a particularly serious problem due to their high vulnerability during early life stages and long population regeneration times. The importance of these larval and juvenile fish cannot be underestimated since they form the biological foundation for recruitment into the adult population. Confidence in available models is reduced since impact assessments based on model predictions have not been independently verified in field studies. Despite these drawbacks, predictive models serve an important function in integrating available data and providing an estimate useful in evaluating the impact (assessment) of a particular project.

In the process of developing impact estimates from mathematical models, it has become apparent that there is a need for standardization of information concerning engineering, water quality, and ecological data. Data are needed to evaluate once-through cooling systems and alternative technologies. A great deal of work on entrapment and impingement of fish in power plant cooling systems either has not been published or is contained only in reports which have limited distribution. Data omission and lack of statistical accuracy in many existing reports makes interpretation of available information exceedingly difficult.

Information on the mechanisms of population regulation for species subject to intake-related mortality is a prerequisite to evaluating the effect of impingement mortality at the population level. Research defining the temporal and spatial distributions of important species at critical life stages is required to estimate the vulnerability of a species to entrainment, entrapment, and subsequent impingement. An evaluation of the potential biological impact resulting from impingement necessarily involves integration of biological data with physical data on the hydrology, tidal flux, and hydraulics of the particular environmental system in question. Finally, there is a need to assess the impact of entrainment and impingement mortality, natural mortality, and the cumulative effects of multiple mortality sources on the population and recovery potential in the receiving waters. Regulatory decisions are currently based on often inadequate information regarding fish behavior, entrainment and impingement mortality, and the population dynamics of the receiving water ecosystem for determining the environmental impact resulting from power plant cooling systems.

The ultimate consideration—the impact of intake-related mortality on the community dynamics or the trophic structure of the receiving water ecosystem—has not been determined. Evaluation of short- and long-term responses of organisms directly affected by entrainment, entrapment, or impingement are required to determine subtle alterations in trophic interactions and energy flow through the aquatic ecosystem in the receiving waters. Research devoted to determining population recovery potential and mechanisms of biologic compensation—mechanisms which allow the populations to compensate for natural disturbances and the effects of man's activities on the environment—is required for precise estimation of ecosystem effects resulting from damage to entrained organisms. Until information on natural mortality, predation, disease resistance, and long-term survival is available for each life history stage of species entrained, entrapped, or impinged in cooling water systems, little confidence can be placed in estimates of ecosystem effects due to damage to these organisms. The present level of knowledge on the interrelationships between aquatic species, the carrying capacity of the ecosystem, and the aquatic environment hinders the evaluation of the impact of intake mortality on the total aquatic resource.

CONSIDERATIONS OF INTAKE SITING AND DESIGN

Intake structures are the first engineering interface between a power plant cooling system and the source of cooling waters. It is at this interface that engineering feasibility and ecological constraints have a considerable influence on design criteria which reduce entrainment, entrapment, and impingement of fish. Design criteria include the following factors: specific site characteristics, cooling system designs, and design of the cooling water intake. In general, three basic strategies exist for minimizing the impact of a cooling-water intake on the aquatic ecosystem and fisheries resources (see footnote 5):

1) minimizing the probability of organisms encountering the intake through site evaluation and intake location;
2) minimizing the volume of water withdrawn and reducing intake approach velocity; and
3) maximizing organism survival through use of fish protection devices incorporated in behavioral or physical barriers.

In the sections which follow we briefly discuss each of these strategies and review several of the major types of fish guidance and diversion systems which are applicable to power plant cooling water intakes.

Site Evaluation

Through comprehensive site evaluations, intake mortality can be minimized by avoiding areas of high fish population densities. Baseline information on the temporal and spatial distribution of motile organisms, diel and annual migration patterns, and cyclic reproduction is vital to avoid power

plant siting on critical spawning and nursery areas or on migratory pathways. Site evaluations require analysis of the most favorable intake and discharge locations to avoid areas of high density stratifications of aquatic organisms. Furthermore, site evaluations should determine potential maintenance problems resulting from biofouling accumulations and deterioration of cooling system components. Preoperational site evaluations must, in addition, lead to cooling system designs which minimize the probability of organisms being reentrained or recirculated as a result of basic geographic or hydraulic characteristics of the site.

Critical analysis of preoperational and operational follow-up studies must be conducted using appropriate quantitative techniques for statistical comparisons. This has been wanting in many impact studies. The development of information documenting changes in community structure over a sufficient time period is one fundamental approach to improving environmental analyses. Numerical indices of community composition and diversity are often useful in evaluating such changes. Supplemental indicators may be derived from commercial and recreational fisheries data which are particularly valuable for evaluating historical trends for selected species. In conjunction with fisheries records, techniques of mark-recapture, stock and recruitment analyses, and resource exploitation provide indicators applicable in defining population dynamics, seasonal abundance, migration patterns, and resource utilization; each contributing to the environmental assessment as well as providing information useful in resource management.

Cooling System Design

Two fundamental power plant cooling system designs exist—once-through cooling and closed-cycle cooling. Closed-cycle cooling, proposed as the best available approach for minimizing adverse effects of power plant cooling on aquatic resources (see footnote 5), offers two principal advantages over once-through cooling systems. Closed-cycle cooling requires 3-14 percent of the water volume needed for once-through cooling, thus resulting in a substantial decrease in the magnitude of phytoplankton, zooplankton, and ichthyoplankton entrainment. In addition, the intake approach velocity can be decreased in those power plants utilizing closed-cycle cooling thus reducing the magnitude and severity of fish entrapment and impingement. However, closed-cycle cooling—utilizing either cooling towers or cooling ponds—is expensive to install and maintain in existing and proposed power plants. Furthermore, cooling towers are not aesthetically pleasing—a factor which must be taken into consideration in cooling system design. In light of these factors and additional considerations regarding closed-cycle cooling (i.e., problems of icing, fog, etc.), we conclude that off-stream cooling may not, in all cases, represent the most efficient design for a particular site and that all potential alternative methods should be considered.

Guidance and Diversion Systems

Two philosophies exist regarding the design of fish protection devices for maximizing the survival of organisms encountering a cooling-water intake. The first focuses on utilizing the behavioral response of the organisms (i.e., guidance or avoidance responses) to a variety of behavioral barriers which guide or divert organisms into bypass channels. This approach, however, requires a predictable behavioral response in order to be effective. The alternative approach utilizes a positive physical barrier to completely block the passage of entrained or entrapped fish. This technique relies on impinging fish for brief periods while the fish are mechanically transferred to a bypass channel. It is our opinion that the most efficient intake systems for minimizing adverse effects on fish utilize a combination of behavioral and physical barriers.

The primary objective to be considered in evaluating any intake system is its ability to remove fish quickly while maintaining maximum survival. The system should, in addition, be effective in preventing passage of diverse fish species and life stages over a wide range of temperatures, flow conditions, and light levels. The demands of these criteria make it exceedingly difficult for an engineer or a biologist to design an intake system which minimizes a potentially deleterious impact upon biological systems. The wide variety of aquatic habitats and fish populations has also contributed to this difficult task. Compilation and synthesis of available information on both behavioral and physical barriers represents a summary of state-of-the-art information relative to intake and screening structures. The discussion of principal cooling water intake systems which follows, although not comprehensive, summarizes biological, engineering, and mechanical considerations of major intake designs.

Behavioral Barriers

The behavioral response of fish to physical stimuli such as light, sound, velocity gradients, or electric shock varies between species of fish, as well as within a species due to differences in age or physiological state (Sonnichsen, 1975). This diversity of behavioral patterns among fish compounds diversion problems encountered at cooling system intakes. Thus behavioral barriers may have their greatest application when used in combination with conventional intake systems (e.g., vertical traveling screens, etc.) particularly during periods when vulnerable species are abundant.

Light

Intense illumination was characterized by Bibko et al. (1974) as a passive deterrent for striped bass, *Morone saxatilis*, only temporarily deterring fish passage under experimental conditions. Fields (1966), reported the avoidance response of salmonids to artificial light varied, depending on the light adaptation of the species, water clarity, and flow conditions. Constant light was more effective than interrupted or flashing light for guiding young salmon. Adaptation of fish to light intensity substantially decreases the guidance efficiency of light barriers.

It has been speculated (Grimes, 1975; Brehmar, pers. commun.), that

light may attract fish into intake systems of many power plants during hours of darkness. Attraction and subsequent entrapment of fish at lighted intake systems at night has not, however, been adequately documented.

Sound

Sonic techniques for repelling fish from industrial water intake structures have been reported by Burner and Moore (1953, 1962), Moore and Newman (1956), VanDerwalker (1964), and Trefethen (1968). Moulton and Backus (1955) reviewed the literature regarding the guidance efficiency of sonic barriers.

In general, maximum avoidance response has been observed with low frequency, high intensity sound; however, variation in hearing ability among species and high-level background noise lead to poor repeatability of the behavioral response of fish to sonic barriers. Burner and Moore (1962) reported the behavioral response to frequency or intensity of sound was insufficient to be effective in guiding young salmonids to safe passage around dams and diversions. The Virginia Electric and Power Company attempted to use relatively high intensity, multifrequency sound to repel fish from power plant intakes (J. C. White, pers. commun.). It was concluded that, although sound was partially effective, sound alone was inadequate for repelling fish from the cooling-water intake due to the diversity of species and sizes of fish encountered and the diversity of behavioral response patterns.

Velocity Gradients

Kerr (1953), Clay (1961), Bates (1964), Bates and VanDerwalker (1964), Niggol (1964), and Prentice[7] discussed flow acceleration or deceleration barriers for guiding or deflecting fish. Flow acceleration barriers produce an increase in approach velocity over a relatively short distance by use of wedges in approach channels. Bates and VanDerwalker (1964), reported a 70 percent diversion efficiency of an experimental waterjet deflector at an approach velocity of 76 cm/s. High diversion efficiencies (81 percent) have been reported by Prentice and Ossiander (1974) for vertical flow accelerators oriented at a 20° deflection angle for channel velocities ranging from 37 to 73 cm/s. Horizontal flow accelerators had an average deflection efficiency of 56 percent for channel velocities from 46 to 79 cm/s. No difference in diversion efficiency was observed between tests conducted during the day and night. Blinded fish, tested by Gerold and Niggol (1964), were guided by flow acceleration barriers and diversion efficiencies comparable to normal fish were observed. Demands of high waterjet volumes, extensive maintenance, and fluctuating hydrologic conditions, however, make waterjet and flow barriers impractical as diversion systems.

The avoidance response of fish to areas of rapidly changing velocity has been proposed to explain the effectiveness of louver systems in diverting fish (Maxwell, 1973). Weight (1958) observed that although fish perceive and respond to horizontal changes in water velocity, they are relatively insensitive to vertical velocity changes. As a result of these observations a "velocity cap" was developed and installed in offshore intakes at several southern California and Great Lakes power plants. The velocity cap acts to convert vertical water movement into a horizontal flow. Reduced fish entrainment and entrapment has been reported under experimental (Weight, 1958) and actual operating conditions (Maxwell, 1973) using the velocity cap.

Bubble Screens

Air-bubble screens have generally been reported as unsuccessful at consistently diverting fish (Brett and MacKinnon, 1953; Fields, 1966; Mayo, 1974). However, several cases have been reported where partial success was observed. Bibko et al. (1974) reported that striped bass, *Morone saxatilis,* would not actively pass through an air-bubble screen at 4.5° or 11.1°C, but were found to drift passively through air-bubble screens when the water temperature was 0.8°C. Striped bass were found to pass through an air-bubble screen at all test temperatures if openings 5.1 cm or greater were allowed in the screen. Shad, *Dorosoma cepedianum,* would not pass through an air-bubble screen at a water temperature of 11.1°C, but were not deterred at 0.8°C (Bibko et al., 1974). Bates and VanDerwalker (1969), studying juvenile migrant salmon (*Oncorhynchus* spp.), reported air-bubble screens produced diversion efficiencies up to 95 percent during daylight but declined in efficiency to 28 percent at night. Poor diversion efficiency at night was not improved by artificial lighting. Alevras (1974) observed that an air-bubble screen at the Indian Point Nuclear Power Plant on the Hudson River did not repel fish during the daytime; and that, based on preliminary data, the air-bubble screen may attract fish during periods of darkness.

Electric Barriers

Electric barriers have been used to divert fish from several small power plants, dams, irrigation canals, and municipal water supply systems with variable success. Holmes (1948) discussed the history, development problems, and practical applications of electrical techniques for fish diversion. Applegate et al. (1954) reviewed the literature on electric barriers.

Pugh (1962), Pugh et al. (1964), and Elliott (1970) reported pulsed current was most effective in terms of guidance, diversion, and power requirements. The behavioral reactions of fish to an electric field are: 1) scare mode or avoidance response, 2) electrotaxis, and 3) electronarcosis leading to paralysis and eventual fish death (Applegate et al., 1954; Elliott, 1970; Maxwell, 1973). In general, the required current density and resulting behavioral response varies between species and sizes of fish (Pugh, 1962; Pugh et al., 1964).

Trefethen (1955) reported moderate guidance efficiency of electrical barriers (68 percent) in large-scale laboratory experiments using fingerling salmon (*Oncorhynchus* spp.) Guidance efficiency for salmonids decreased as water velocity exceeded 15 cm/s

[7]Prentice, E. F. 1966. Response of juvenile salmonids to four flow accelerator wedge geometries. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Northwest Fish. Cent., Seattle, Wash. Unpubl. manuscr.

(Pugh, 1962; Pugh et al., 1964). Maxwell (1973) reported variable success of electric barriers used at small intakes on fresh water, usually with resident rather than migrating fish species. Due to the low electrical resistance, no application of electric fish barriers has been made in salt or brackish waters.

Physical Barriers

Water intake system design criteria are similar for industrial or hydroelectric usage, irrigation or pump storage facilities: 1) elimination of entrained fish from industrial waters while preventing fish loss due to entrapment, impingement, and mechanical injury, either singly or in schools; 2) removal of entrained debris; and 3) mechanical dependability of the intake system. The application of technology and experience gained at hydroelectric dams and water diversion projects has proven to be of considerable value in design and evaluation of steam electric generating station cooling-water intakes.

Stationary Screens

Stationary screens have long been used in irrigation canals and industrial water intake systems. Debris accumulations at the screen surface reduce water volume and efficiency of these screen installations which, in addition, offer no bypass facility, thus completely blocking the passage of fish.

Vertical Traveling Screens

Vertical traveling screens have been used in hydroelectric dams and steam generating power stations for many years. These screens have proven to be a reliable method of eliminating debris from power plant cooling waters. Through proper design and installation, vertical traveling screens provide a positive barrier for juvenile and adult fish; successful diversion of fish eggs and larvae has not, however, been achieved. Screen rotation carries impinged fish into bypass facilities and provides self-cleaning of debris. Vertical traveling screens are commonly inclined 20° to 30° in hydroelectric dams in an attempt to guide fish to bypass facilities (Marquette and Long, 1971; Bell, 1973; Eicher, 1974; Farr, 1974; and Mayo, 1974). At steam electric power stations, however, screens are oriented vertically to the water flow, thus increasing problems associated with fish impingement. In addition, vertical traveling screens at many power plant intakes have been recessed within cul-de-sac approach channels which serve to entrap fish. In general, vertical traveling screens have proven to be a relatively good engineering and biological design, not greatly affected by fluctuations in water level.

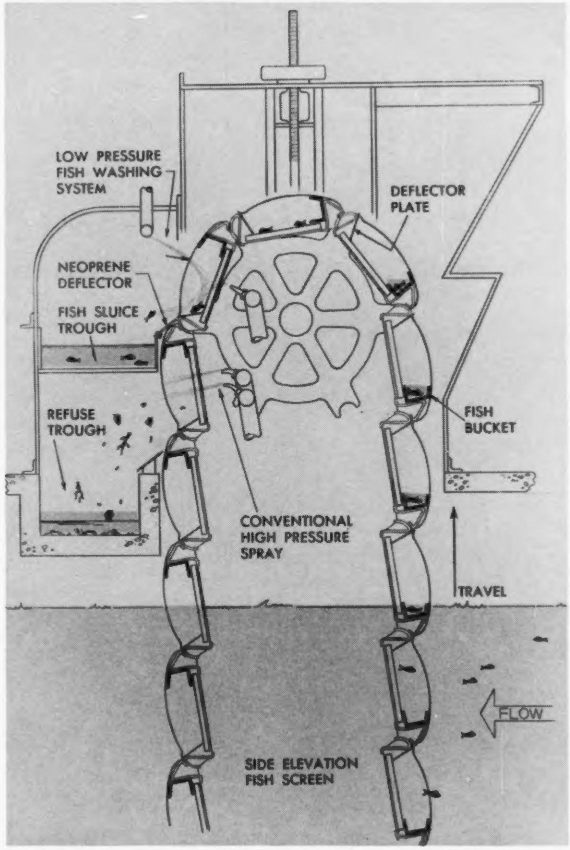

Figure 1.—Diagram of a vertical traveling screen and fish salvage system. (Photo courtesy of Envirex, Division of Rexnord Company, Waukesha, Wis.)

Research to improve the diversion efficiency and survival of screen-impinged fish is currently underway. Prentice (1974) presented a design concept (Fig. 1) for a vertical traveling fish basket collector and rubber scraper to aid in screen cleaning. A similar fish basket collector installed on traveling screens at the Chesterfield Power Station on the James River appears to have reduced impingement mortality. (J. C. White, pers. commun.) Fish impingement mortality has also been reduced by implementation of high volme, low pressure spray jet wash systems on vertical traveling screens. Research is currently underway on the design of fish bypass systems, the rate of screen rotation, and the use of inclined screens with pump augmented bypasses as proposed by Eicher (1961).

Horizontal Traveling Screens

The horizontal traveling screen (Fig. 2) developed by Bates (1969) has been proposed for fish diversion in canals, hydroelectric dams, and irrigation intakes. The National Marine Fisheries Service is developing and testing prototype screen designs applicable for power plant intakes.

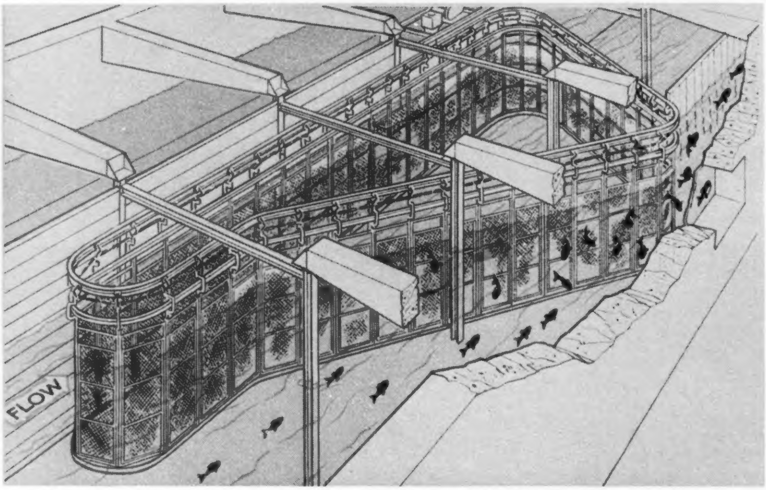

Figure 2.—Diagram of a horizontal traveling fish screen. (Photo courtesy of Envirex, Division of Rexnord Company, Waukesha, Wis.)

Major attributes of the horizontal traveling screen concept include: 1) formation of a complete physical barrier, 2) high diversion efficiency of juvenile migrant fish, and 3) release of impinged fish into a bypass without passing the air-water interface. Operation of horizontal traveling screens is not greatly affected by fluctuations in water depth. The screen is self-cleaning, thus minimizing head loss, and is capable of operating under higher approach velocities than normally possible with other types of screening installations. Research and development of the horizontal traveling screen has been reported by Bates (1969), Bates et al. (1970), Farr and Prentice (1974), and Prentice and Ossiander (1974).

Prentice and Ossiander (1974), studying 70-mm fingerling salmonids (*Oncorhynchus tshawytscha*), observed 97.9 percent diversion efficiency of a traveling screen 30° to a flow of 46 cm/s under lighted conditions and a 91.5 percent diversion efficiency under dark conditions. Diversion efficiency of 170-mm salmonids tested under similar conditions were 99.6 and 99.8 percent during the day and night tests, respectively. No screen impingement was observed during these tests; 48-h posttest survival exceeded 97 percent for all experiments.

Mechanical performance is not, at present, acceptable for continuous operation of a horizontal traveling screen at a power plant intake. Prototype tests designed to examine mechanical operation and to assess performance limitations are discussed by Farr and Prentice (1974). Solutions to mechanical problems resulting from suspended sediment and sediment bedload have yet to be perfected.

Vertical Drum Screens

Vertical drum screens have been used for fish diversion in irrigation canals and in British steam electric stations for protection of salmonids with variable success (Eicher, 1974). Vertical drum screens having diameters of approximately 3 m are commonly aligned in rows leading to a bypass channel. Screen rotation carries impinged fish toward the bypass and provides debris self-cleaning. Vertical drum screens provide a positive barrier for adult and subadult fish but do not appear to be acceptable for the protection of eggs and larval fish. Fluctuations in water depth do not affect the performance of vertical drum screens.

Horizontal Drum Screens

Horizontal drum screens have been used for fish diversion in irrigation facilities, power plants, and hydroelectric projects as discussed by Maxwell (1973), Eicher (1974), and Mayo (1974). These well developed and proven screens provide a positive barrier for adult and subadult fish. Horizontal drum screens are not, however, acceptable for protection of fish eggs or larvae. Self-cleaning of debris from the screen surface is achieved through screen rotation which has proven to be detrimental to impinged fish if no bypass facility is provided. Diversion efficiency of horizontal drum screens is sensitive to fluctuating water levels.

Perforated Plates

Perforated plates provide a positive barrier for adult and subadult fish and hold the potential for protection of eggs, larvae, and juvenile fish (Wales et al., 1950; Maxwell, 1973). Perforated plate diversions incorporate a simple design concept and operation into a system which is not affected by changes in water surface level. Perforated plates are, however, not self-cleaning and thus require back washing and mechanical removal of debris and biofouling accumulations. Additional research is required to establish biological design criteria and to evaluate the diversion efficiency for perforated plates under various approach velocities and flow conditions.

Rapid Sand Filter

The high capacity rapid sand filter (Fig. 3) has the potential to prevent entrainment, entrapment, and impingement of all species and life stages of fish in power plant cooling systems. Free flow across the filter surface and low approach velocity combine to eliminate potential fish kills and the need for handling and disposal of trash.

A prototype high capacity rapid sand filter was tested as a method for the exclusion of larval fish from thermal power plant cooling system intakes by Stober et al. (1974). Hydraulic and biological characteristics of seawater filtration through an anthracite-gravel filter were examined. Filter flow velocities of 0.30 to 0.61 cm/s did not result in sink flow rates affecting the vertical or lateral mobility of juvenile fish and larger vertebrates above the filter surface. Test data were utilized to

determine the engineering feasibility and probable requirements for construction, operation, and maintenance of a rapid sand filter design concept capable of providing cooling water at a rate of 42 m^3/s for a 1,000 MWe nuclear power plant (Strandberg, 1974). Continuous operation of a prototype high capacity rapid sand filter over one annual cycle would be desirable to provide additional data to determine biological and engineering feasibility and provide operating and maintenance experience prior to final design evaluations.

FUTURE CONSIDERATIONS

The need for future research into the complex problems of fish entrainment, entrapment, and impingement is put into perspective by the magnitude of the problem. Estimates of 179 million fish larvae and juveniles entrained per year at the Connecticut Yankee Power Plant, 150 million eggs and 100 million larvae entrained into the Oyster Creek Power Plant per year, to name but two cases, speak for themselves. Furthermore, entrapment-impingement mortalities approaching or exceeding 1 million fish per year have been documented at several power plants. The problems associated with documenting fish losses and, more importantly, predicting the impact of such losses on aquatic resources are complex and it would be naive to imply the existence of a quick or simple solution. The demand for extensive research into this problematic area is evident.

A prerequisite to meeting future research demands is to overcome the problems of interdisciplinary communications and open channels of cooperation between biologists, engineers, and political decision makers. The flow of data and ideas between these groups will greatly improve the results of future research efforts. This interdisciplinary approach—directed toward solutions to particular problems—demands the commitment of strong political and economic support.

It is apparent from preceeding sections that, at present, our understanding of environmental perturbation permits little more than an acknowledgement of the problem. In addition, difficulties in extrapolating generalizations from one site to another has plagued researchers and decision makers alike. The fundamental problem which must be faced in future research is that of prediction. In the process of developing predictive estimates it has become apparent that there exists a considerable need for standardization of information including relevant engineering, water quality, and ecological data. Data omission and lack of statistical accuracy in many existing reports make interpretation of available information, upon which predictive estimates and licensing regulation decisions are based, exceedingly difficult.

The principal conclusion of this review is that estimates of the short- and long-term impacts of a proposed power plant will depend upon developing better simulation models. In considering the present state of model simulations, we have pointed out areas which need refinement, omissions, and limitations of our present knowledge. Future research should focus on examining basic behavioral and physiological mechanisms associated with entrapment and impingement in combination with ecological processes of those populations and communities influenced by proposed and existing projects. Such an approach requires integration of laboratory studies concerning the interrelationship between hydraulics, orientation behavior of fish, sensory physiology, and fish energetics, all of which would provide a broader basis for developing intake structure design criteria. Complementing laboratory

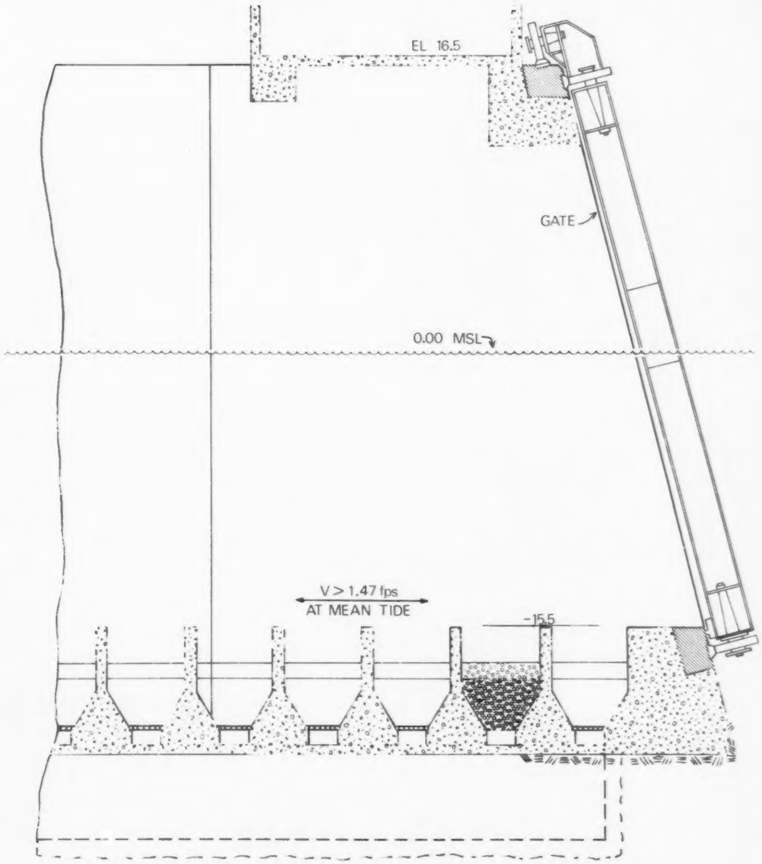

Figure 3.—Longitudinal cross section of a rapid sand filter. (Photo courtesy of Q. J. Stober.)

studies is field research into mechanisms and processes involved in recruitment, biological compensation, population dynamics, and community response to environmental perturbations. Coordination of field site evaluations and predictive laboratory investigations will provide data essential for developing predictive models for optimizing intake design and locations.

The utility of field data depends largely on the integrity of the sampling scheme. In general, sampling should be sufficient to establish statistical accuracy (i.e., confidence limits, sampling error, and variance). The sampling scheme should focus on identifying critical development stages of organisms and their vulnerability to entrainment, entrapment, and impingement damage. In this regard, information on the temporal and spatial distribution of organisms, diel, seasonal, and annual migration patterns, and reproductive cycles is vital to avoid power plant siting on critical spawning and nursery areas or migratory pathways.

A problem common to both field studies and predictive modeling is that of natural variability. Natural populations fluctuate seasonally and annually in response to environmental conditions. Such natural fluctuations and variability (both temporally and spatially) necessitate field studies be conducted for at least 3 yr to estimate the magnitude of natural variability. In addition, it is exceedingly difficult, without extensive baseline data, to determine whether fluctuations in populations or community structure reflect the impact of power plant-related damage or are the result of natural variability. The "masking" effect of natural variability becomes particularly serious when considering the long lag time—measured in years or decades—before chronic, low-level mortality resulting from entrainment, entrapment, or impingement may be recognized. By the time such damage is realized the population dynamics or trophic structure of the receiving water ecosystem may be significantly altered. The "masking" effect of natural fluctuations requires a great deal of future consideration and must be analyzed if predictive estimates are to be refined.

Predictions and environmental analyses are further complicated since natural surface waters often support a multiplicity of uses. For example, a river or estuarine system may be used as a source of cooling waters for one or more electrical generation stations, as receiving waters for the discharge of municipal sewage, for intense commercial fisheries, for recreation, or other purposes. Examination of the potential impact of a proposed power plant out of context with other demands on the system lead to misunderstanding and possible mismanagement of the aquatic ecosystem.

Throughout the preceeding discussion we have concentrated on the biological aspects of power plant siting with little mention of the input of model predictions and ecological concerns into the decision making process. As biologists we are often asked to express environmental loss or ecological damage in terms of a dollar value. The concept and philosophy of monetary value as the least-common-denominator in a cost-benefit analysis warrants a great deal of future consideration. Equating the value of a fisheries resource or aquatic community against the cost of building cooling towers or loss in revenue, jobs, and electrical supply is one major component of environmental analysis which must be approached with extreme caution.

CONCLUSION

It is apparent from the available literature that there exists a need for systematic studies which provide biological and hydraulic criteria for design and evaluation of major water intake systems. Historically, an empirical trial-and-error approach has been used in the design of agricultural and industrial water diversions and associated fish protective facilities. This approach has resulted in a serious lack of basic information and rigorous experimental research concerning the interrelationship between hydraulics, orientation behavior of fish, sensory physiology, and fish energetics, all of which would provide a broader basis for developing intake structure design criteria. The need is clear, as well as urgent, to develop more sensitive, informed, and responsible approaches to the design, evaluation, and management of existing and future cooling water intakes.

In summary, ecological research on the entrapment and impingement of fish by power plant cooling-water intakes is in an embryonic state of development. A nucleus exists, founded on an interdisciplinary approach to finding ways to minimize environmental impact, upon which future research can be based. Two issues of major importance which must be addressed in future research include: 1) what effect, if any, does the entrapment or impingement of fish have on the productivity of the aquatic ecosystem or the fisheries resources; and 2) what criteria determine the best available intake-design technologies for minimizing effects on aquatic life and assuring continued balance of diverse aquatic ecosystems.

Decisions regarding these and other pertinent environmental-engineering issues should be founded on objective, concise, and clearly defined research data. Recommendations should be considered in perspective with the economic and social demands of our times as well as our responsibility to the future.

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MFR PAPER 1267

Development of a Selective Shrimp Trawl for the Southeastern United States Penaeid Shrimp Fisheries

JOHN W. WATSON, Jr. and CHARLES McVEA, Jr.

ABSTRACT—Preliminary designs and evaluations are presented of experimental selective shrimp trawls for use in the southeastern United States penaeid shrimp fisheries. Based upon behavioral observations of shrimp and fish in operating trawls, a "V" type vertical separator panel was developed to separate shrimp from fish. Separator panels placed in the trawl wings led bycatch organisms to a fish escape chute and used water flow patterns within the trawl to selectively capture shrimp. Six separator panels were evaluated to find the mesh size and shape for maximum fish separation and minimum shrimp loss. Secondary separation techniques to eliminate fishes not separated by the separator panels were also evaluated.

INTRODUCTION

This is an interim report on the research and development of trawl designs and separation techniques to achieve mechanical selection of shrimp by modifying, improving, or redesigning panel-type selective trawl designs. The results provide baseline data for the further development of an effective prototype selective shrimp trawl design.

The need for a selective shrimp trawl for the southeastern United States penaeid shrimp fishery was presented by Seidel (1975). The overlap between fishing grounds of demersal finfish and shrimp fisheries in this area has produced a significant discard problem detrimental to both industries. Incidental finfish capture during shrimping operations has resulted in discard rates of 3-20 pounds for each pound of shrimp caught (Juhl et al., 1976). This results in wasteful destruction of commercial quantities of several industrial fish species, in addition to increased labor for the shrimp fishermen who must sort the catch.

One solution to the problem of discards is to develop a selective shrimp trawl for capturing shrimp and releasing the bycatch unharmed. Thus, the National Marine Fisheries Service (NMFS), Southeast Fisheries Center, Pascagoula Laboratory, has begun research on a selective shrimp trawl for the southeastern penaeid shrimp fishery.

The first approach in designing a selective trawl was to evaluate existing separator trawls. Development of selective shrimp trawls began in France and the Netherlands in 1964. Selective trawls were also used in Belgium, Norway, Iceland, and the northwest United States on crangonid and pandalid shrimp in the 1960's. Summation of existing selective trawl designs and operational achievements were presented in an FAO (Food and Agriculture Organization of the United Nations) Fisheries Report in 1973. The European horizontal separator panel design trawl (Food and Agriculture Organization, 1973) and the Northwest Fisheries Center (NWFC) vertical separator panel design trawl (High et al., 1969) were evaluated on commercial shrimp grounds in the northern Gulf of Mexico. The European horizontal panel trawl separated finfish adequately but produced poor shrimp catches. The NWFC vertical panel trawl produced similar results, and the vertical separator panel placed across the trawl mouth clogged easily, decreasing separating efficiency. The problems encountered with the introduction of these trawl designs to the southeastern United States penaeid shrimp grounds stem from the similar size of fish and shrimp characteristic to this region, and are intensified by the abundance of fish in the catches. In the crangonid and pandalid fisheries, shrimp total lengths range between 30 mm and 70 mm and may compose up to 90 percent of the total catch. The penaeid shrimp are larger (100-230 mm total length) and may compose only 10 percent of the total catch. Fish species diversity and size range associated with the penaeid shrimp fishery make separation extremely difficult.

MATERIALS AND METHODS

Scientist/divers of the Harvesting Technology Task, Southeast Fisheries Center, have observed shrimp and fish behavior in trawls (Watson, 1976). It was observed that shrimp are weak swimmers and are unable to maneuver against the water flow generated by operational gear (Fig. 1). As the trawl is fished, shrimp are impinged against the trawl wing and then tumble down the wings into the bag. Because fish are stronger swimmers, they swim ahead of or lead along the approaching trawl wings and eventually maneuver to an area of less turbulent water near the trawl bag.

Utilizing these observations of water flow patterns and fish/shrimp behavior, a panel was designed to separate the shrimp from the fish. The "V" design vertical separator panel is a modification of the NWFC vertical panel. The V panel design was initially evaluted (Fig. 2) in a 16-foot model trawl to find the correct panel placement. It was then scaled up to a 12-m (40-foot headrope)

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Table 1.—Specifications for separator panel designs.

Panel code	Mesh size	Stretch mesh size
S_1	3.2 cm (1¼ inch) square	6.4 cm (2½ inch)
S_2	3.8 cm (1½ inch) square	7.6 cm (3 inch)
S_3	4.4 cm (1¾ inch) square	8.9 cm (3½ inch)
R_1	2.9 × 5.7 cm (1⅛ × 2¼ inches)	5.7 cm (2¼ inch)
R_2	3.2 × 6.4 cm (1¼ × 2½ inches)	6.4 cm (2½ inch)
R_3	2.5 × 7.6 cm (1 × 3 inches)	5 cm (2 inch)

Gulf of Mexico, four-seam, semiballoon shrimp trawl (Bullis, 1951; Food and Agriculture Organization, 1972). Correct placement and adjustment of the V panel in a full-sized trawl required numerous modifications accomplished by scientists/divers using trawl evaluation techniques described by Wickham and Watson (1976).

Experimental trawl design specifications are shown in Figure 3. The V type panel is laced into the trawl in two sections beginning at the trawl wings and following the top seam of each wing 36 meshes. Panels are then laced to a straight line of meshes which intersect at the top center of the trawl, 166 meshes back from the center of the headrope. Panel sections are then joined to an escape chute which leads to an opening in the top of the trawl. The separator panel length, width, and placement are critical to the proper opening of meshes necessary for shrimp separation.

In the laboratory, we used a flume tank to find the optimum mesh size and shape to allow shrimp to pass through the separator panel. Shrimp in the tank were forced by a constant 2½-knot current against webbing of various mesh sizes and shapes to determine optimum panel characteristics. We found that a mesh size between 3.2 cm (1¼ inches) and 4.4 cm (1¾ inches) square, or a rectangular-shaped mesh between 2.9 cm × 5.7 cm (1⅛ × 2¼ inches) and 2.5 cm × 7.6 cm (1 × 3 inches) allowed the maximum separation of shrimp between 100 mm and 200 mm in length.

Six panels were selected for field evaluations (Table 1). Panels S_1, S_2,

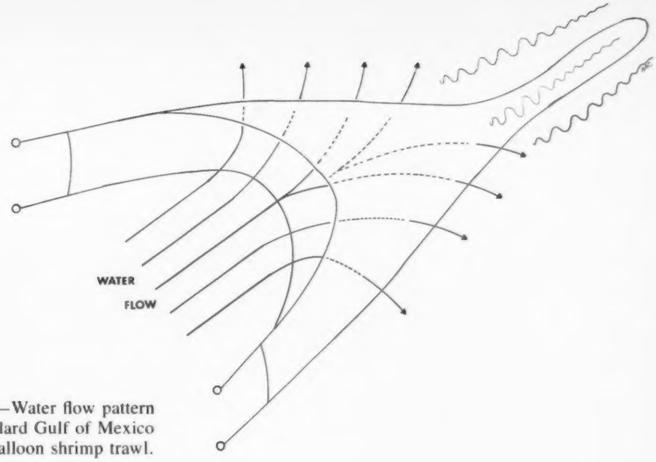

Figure 1.—Water flow pattern through a standard Gulf of Mexico semiballoon shrimp trawl.

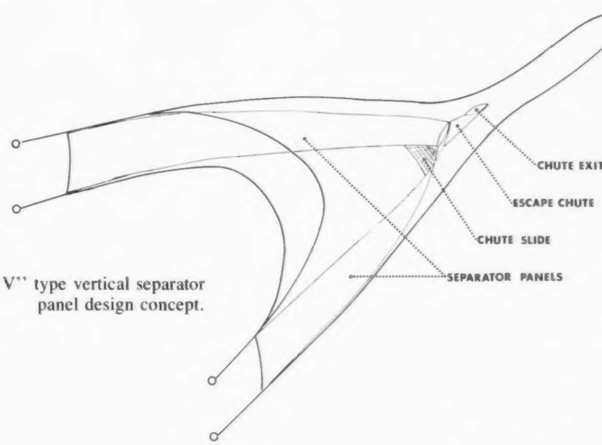

Figure 2.—"V" type vertical separator panel design concept.

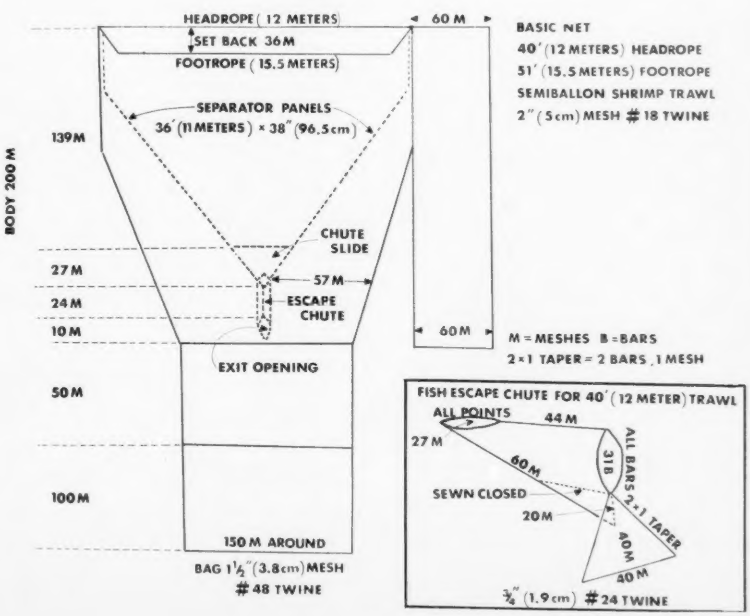

Figure 3.—40-foot selective shrimp trawl design diagram.

Table 2.—Average catch weights and total bycatch separation and shrimp loss rates for experimental trawl designs and corresponding control trawls.

Panel design	No. drags	Bycatch weight (lb/h) Experimental	Bycatch weight (lb/h) Control	Shrimp weight (lb/h) Experimental	Shrimp weight (lb/h) Control	Bycatch separation rate (%)	Shrimp loss (%)
S_1	7	38	203	10	26	81	62
S_2	10	58	106	15	16	45	6
S_3	13	94	152	15	17	38	12
S_2 with FED	10	67	190	16	23	65	30
R_1	12	83	159	18	22	48	18
R_2	18	112	302	24	28	63	14
R_3	17	103	170	18	20	39	10
R_2, I skylight	13	78	144	15	18	46	17
R_2, II skylight	6	89	158	13	15	44	13
R_2, III skylight	11	204	380	14	17	46	18

Table 3.—Average size of bycatch species and shrimp mean lengths for experimental panels S_1, S_2, and S_3 and their corresponding control nets.

Species	Panel S_1	Control	Panel S_2	Control	Panel S_3	Control
Synodus foetens[1]	136	132	122	109	86	123
Arius felis			50	77	64	86
Serranus atrobranchus	14	9	18	14	9	9
Centropristis philadelphica	68	66	54	68	64	59
Cynoscion arenarius	163	227	118	109	145	150
Cynoscion nothus	109	136				
Leiostomus xanthurus		118	95	100	104	123
Micropogon undulatus	95	123	91	91	127	191
Stenotomus caprinus	14	41	32	45	45	41
Lepophidium sp.	54	41	36	54	45	50
Prinotus rubio	27	36	27	32	36	45
Cyclopsetta chittendeni				91	73	86
Porichthys porosissimus			32	23	36	91
Trichiurus lepturus	77	145				
Callinectes similis		36	14	27	27	32
Penaeus aztecus[2]	138	151	144	148	144	146

[1]Bycatch species size in grams.
[2]Shrimp length in millimeters.

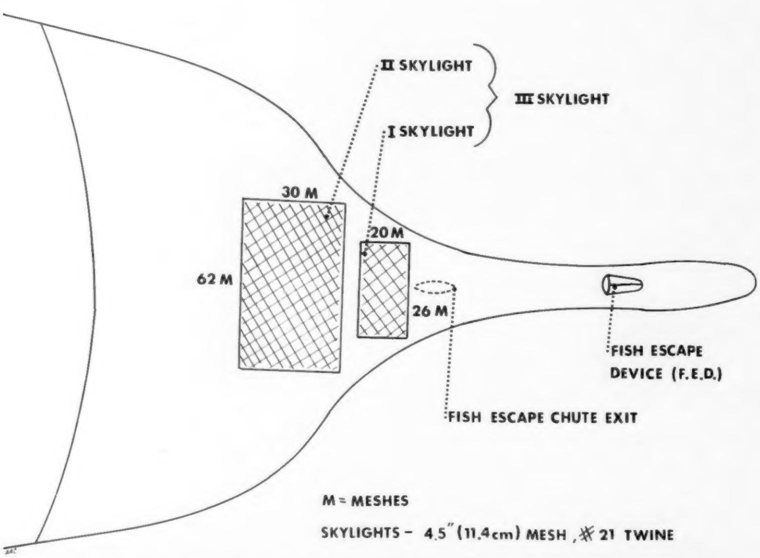

Figure 4.—Secondary fish escape technique employed on the 40-foot selective shrimp trawl design.

and S_3 were made from No. 18 nylon mesh twine hung square. Panels R_1, R_2, and R_3 were made from No. 18 nylon mesh twine hung square and alternate bars removed to create the rectangular mesh shapes.

Two secondary fish removal techniques were also evaluated: 1) Fish Escape Device (FED)—a small wire frame 39 cm (15 inches) long and 19 cm (7.5 inches) in diameter, sewn into the cod end creating a hole through which small fish can escape (Fig. 4); 2) "Skylight"—an 11.4 cm (4.5 inch) stretch mesh webbing panel, placed in the top of the trawl to allow fish escape through the large meshes (Fig. 4).

The V panel designs and secondary fish escape techniques were tested off Louisiana from the fishery research vessels *Oregon II* and *George M. Bowers*.

Each 40-foot experimental trawl was towed simultaneously against a control, four-seam, semiballoon shrimp trawl of the same size. Tows were of 1 hour duration with the catches in both nets sampled to determine total bycatch weight, total shrimp weight, species composition, average weight, and shrimp length frequency. Differences in total bycatch weight and total shrimp weight between trawls were calculated to evaluate effectiveness of the panel designs and secondary escape techniques.

RESULTS

Results of comparative tows between experimental trawls and control trawls are shown in Table 2 and Figures 5-8. Table 2 shows the average catch weights and bycatch separation and shrimp loss rates for experimental trawls and controls. Species composition of those organisms composing more than 1 percent of the catch and separation rates are shown in Figures 5-8. The percent separation for each species was computed as the average difference between the control net and the experimental net catches. The average size of the bycatch species and shrimp mean lengths for the experimental and control catches are shown in Tables 3-6.

Square Mesh Separator Panel Designs

Comparisons of the three square mesh separator panels (Fig. 5) indicate the best bycatch separation rate was obtained with the 3.2-cm (1¼-inch) mesh size (S_1, Table 1). However, this mesh size had the highest shrimp loss (62 percent) because the mesh was too small for adequate separation. Larger shrimp were not being retained, as indicated by the mean shrimp length of 138 mm for S_1 compared with 151 mm for the control trawl (Table 3). The S_2 and S_3 panels had the best shrimp catch rates with very little shrimp loss, and mean shrimp lengths were nearly equivalent for both panels (S_2 and S_3) and their controls (Table 3). The predominant bycatch species caught in control nets were Atlantic croaker, *Micropogon undulatus,* and longspine porgy, *Stenotomus caprinus,* composing 40-45 percent of the total catch (Fig. 5). The S_2 panel separated an average of 69 percent of the croaker and 82 percent of the porgy compared with 57 percent and 49 percent for the S_3 panel. The overall bycatch separation rate for the S_2 panel was better, however, than that of the S_3 panel for all species, except inshore lizardfish, *Synodus foetens;* Atlantic midshipman, *Porichthys porosissimus;* and crab, *Callinectes similis.*

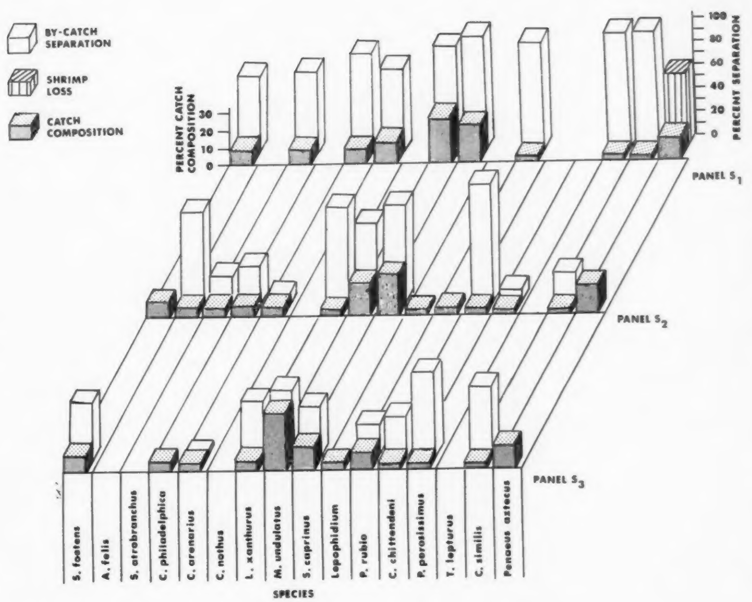

Figure 5.—Species composition, bycatch separation rates, and shrimp loss for the experimental selective shrimp trawl employing square separator panel designs S_1, S_2, and S_3.

Fish Escape Device

The FED (Fig. 4) was installed in a trawl with an S_2 separator panel, and separation rates were determined by comparative tows against a separator trawl with an S_2 panel alone. Predominant species were croaker and longspine porgy (Fig. 6), composing up to 55 percent of the total catch. Results of trawl catches with the FED showed a 9 percent increase in croaker separation and a 6 percent increase in porgy separation when compared with the S_2 panel alone. There was also increased separation of *S. foetens,* blackfin sea robin, *Prionotus rubio,* and *C. similis* with the FED; however, the amount of shrimp loss associated with the FED increased to 29 percent, negating the bycatch separation advantage. Shrimp were lost over the entire size range, as indicated from the mean lengths of shrimp caught in each trawl (Table 4).

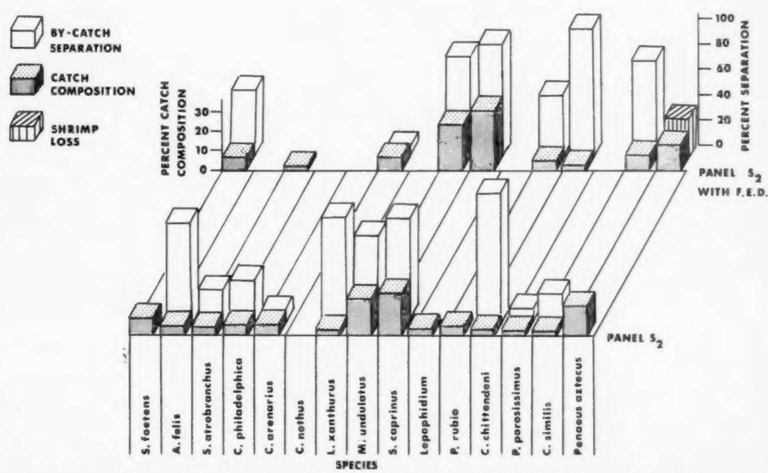

Figure 6.—Species composition, bycatch separation rates, and shrimp loss for the experimental selective shrimp trawl employing the S_2 design panel with and without a fish escape device.

Rectangular Mesh Separator Panel Designs

Comparisons for the three rectangular mesh separator panels (Table 1) are presented in Figure 7 and Table 5. Shrimp losses were only 8 percent for the R_3 panel, 13 percent for the R_2 panel, and 19 percent for the R_1 panel. Shrimp mean lengths were consistent between the experimental trawl and the control catches, indicating no selectiv-

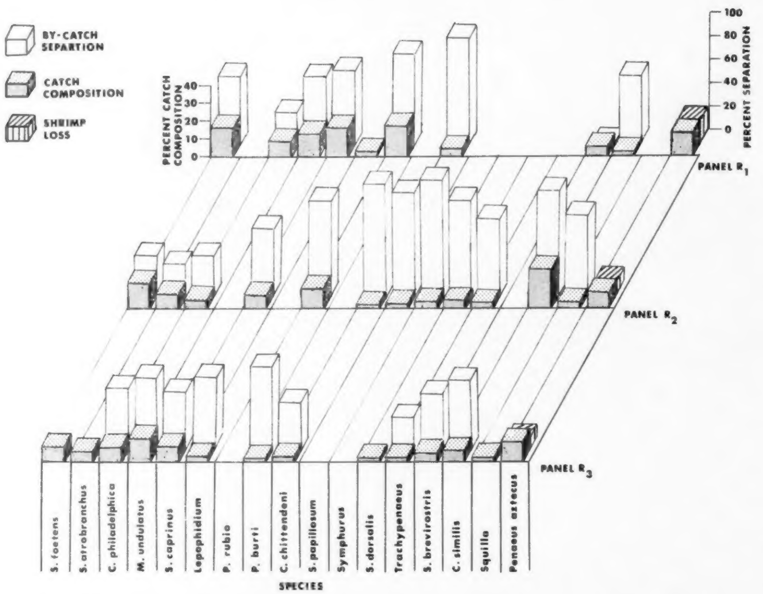

Figure 7.—Species composition, bycatch separation rates, and shrimp loss for the experimental selective shrimp trawl employing rectangular separator panel designs R_1, R_2, and R_3.

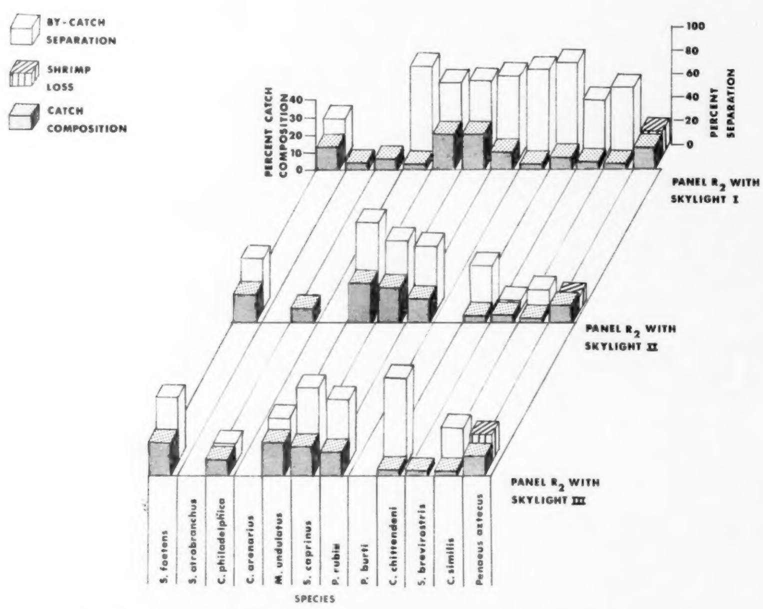

Figure 8.—Species composition, bycatch separation rates, and shrimp loss for the experimental selective shrimp trawl employing the R_2 panel with skylight designs I, II, and III.

ity in the size of shrimp lost. The most abundant bycatch species captured were *S. foetens, Stenotomus caprinus,* and *C. similis,* and the R_1 and R_2 panels had better separation rates for these species than the larger R_3 panel (Fig. 7). The best overall separation rates combined with relatively low shrimp loss rates were obtained by the R_2 panel design.

Skylights

Comparisons between three skylight secondary fish removal designs are shown in Figure 4. The lowest shrimp loss rates were obtained with skylight II which had an average loss of 11 percent compared with 20 percent for skylight I and 24 percent for skylight III (Fig. 8). Comparisons of shrimp length-frequency data for skylight designs showed no shrimp size selectivity (Table 6). Predominant species captured included *Synodus foetens, M. undulatus, Stenotomus caprinus,* and *P. rubio* (Fig. 8), and the best separation rates for these species were obtained by skylight II, which also had the least shrimp loss rate. The separation rates, however, were only slightly larger than those obtained with the R_2 panel alone (Fig. 7).

Initial evaluations of the V separator panels indicate successful separation of shrimp from fish can be obtained by this design. Bycatch separation rates were excellent for most of the dominant finfish species encountered. Separation rates averaged 70 percent for *M undulatus,* 80 percent for *S. caprinus,* 80 percent for sea catfish, *Arius felis,* 80 percent for spot, *Leiostomus xanthurus,* 100 percent for Mexican flounder, *Cyclopsetta chittendeni,* and 60 percent for *C. similis.* These species compose up to 60-70 percent of the shrimp bycatch taken in the Gulf of Mexico (Moore et al., 1970; Juhl et al., 1976) and are essential for continued development of the industrial bottomfish fisheries. *M. undulatus* and *L. xanthurus* compose 75 percent of the exploited fish in the demersal fisheries (Juhl et al., 1976). Other species separated included red snapper, *Lutjanus campechanus,* 80 percent, and southern flounder, *Paralichthys lethostigma,* 100 percent. Although these species made up less than 1 percent of the total catches by weight, they are considered significant because of their economic value as food fish.

Species not separated well by panels with mesh sizes large enough to permit adequate shrimp retention (S_2, R_2) included: *Synodus foetens;* blackear bass, *Serranus atrobranchus;* rock sea bass, *Centropristis philadelphica;* sand seatrout, *Cynoscion arenarius;* cusk eel, *Lepophidium* spp.; *Prionotus rubio;* and *Porichthys porosissimus*. Individually they made up only 2-10 percent of the bycatch but collectively up to 30-40 percent of the total catch.

Body shape and fish size are extremely important to the separation effectiveness of the V panel designs. Species adequately separated are generally the larger fishes or those with laterally compressed bodies (*M. undulatus, Leiostomus xanthurus*, etc.). Species not well separated included the smallest fish (*S. atrobranchus, Centropristis philadelphica, Prionotus rubio*, and *Porichthys porosissimus*) and those with fusiform body shapes (*Synodus foetens* and *Cynoscion arenarius*).

Secondary techniques to improve separation of smaller fish met with limited success. The FED device improved fish separation rates but shrimp losses were unacceptable. Skylights improved separation of finfish but two of the designs had unacceptable shrimp losses. Skylight II, the best design for least shrimp loss, showed only a small increase in finfish separation.

Table 4.—Average size of bycatch species and shrimp mean lengths for panel S_2 with and without the FED and their corresponding control net.

Species	Panel S_2 with FED	Control	Panel S_2 without FED	Control
Synodus foetens[1]	141	136	122	109
Arius felis			50	77
Serranus atrobranchus	14	9	18	14
Centropristis philadelphica	36	41	54	68
Cynoscion arenarius	181	177	118	109
Cynoscion nothus	104	100		
Leiostomus xanthurus			95	100
Micropogon undulatus	113	118	91	91
Stenotomus caprinus	27	36	32	45
Lepophidium sp.			36	54
Prinotus rubio	27	41	27	32
Cyclopsetta chittendeni		118		91
Porichthys porosissimus	27	18	32	23
Callinectes similis	14	14	14	27
Penaeus aztecus[2]	145	148	144	148

[1]Bycatch weights in grams.
[2]Shrimp length in millimeters.

Table 5.—Average size of bycatch species and shrimp mean lengths for experimental panels R_1, R_2, and R_3 and their corresponding control net.

Species	Panel R_1	Control	Panel R_2	Control	Panel R_3	Control
Synodus foetens[1]	82	114	82	73	100	123
Serranus atrobranchus			9	9	9	9
Centropristis philadelphica	27	41	18	23	18	23
Micropogon undulatus	100	100	82	73	109	95
Stenotomus caprinus	32	36	18	18	27	27
Lepophidium sp.	23	32	36	36	32	64
Prinotus rubio	27	54	14	18		
Cyclopsetta chittendeni	95	109	36	118	159	177
Peprilus burti					68	82
Syacium papillosum			27	32		
Symphurus			23	18		
Sicyonia dorsalis			5	5	5	5
Trachypenaeus sp.			5	5	9	9
Sicyonia brevirostris	9	14			9	14
Callinectes similis	14	18	18	27	14	18
Squilla			9	9	14	14
Penaeus aztecus[2]	148	147	125	126	129	130

[1]Bycatch weights in grams.
[2]Shrimp length in millimeters.

Table 6.—Average size of bycatch species and shrimp mean lengths for panel R_2 in combination with skylights I, II, and III and their corresponding control net.

Species	Skylight I	Control	Skylight II	Control	Skylight III	Control
Synodus foetens[1]	118	109	104	100	95	95
Serranus atrobranchus	14	14				
Centropristis philadelphica	32	27	27	41	27	41
Cynoscion arenarius	186	250	186	227		
Micropogon undulatus	118	127	95	95	100	91
Stenotomus caprinus	27	36	27	27	27	27
Prinotus rubio	36	32	32	32	27	32
Peprilus burti	100	68				
Cyclopsetta chittendeni	127	218	136	95	86	109
Sicyonia brevirostris	9	9	9	9	9	9
Callinectes similis	14	18	14	18	18	23
Penaeus aztecus[2]	142	141	151	149	147	148

[1]Bycatch weights in grams.
[2]Shrimp length in millimeters.

SUMMARY

The optimum V panel mesh size and shape for the penaeid shrimp fishery appears to be between the 3.8-cm (1½-inch) square mesh (S_2) and the 3.2 × 6.4 cm (1¼- × 2½-inch) rectangular mesh (R_2). Both panels had good bycatch separation rates for the predominant species. Shrimp loss rates were slightly higher for the R_2 panel than for the S_2 panel. One limitation of the R_2 panel was the unavailability of rectangular shaped webbing. Panels were constructed by cutting alternate bars from a square mesh panel to produce the desired rectangular shape. Cutting meshes from knotted webbing loosened the knots at the point where the bars were removed. This reduced

the effectiveness because large holes were created by the loose knots.

Clogging and gilling of fish were experienced with the experimental designs. Escape chutes occasionally clogged with fish or objects such as logs, tires, etc. Clogging appears to be a function of escape chute length, which is particularly evident when large quantities of fish are encountered. Gilling of fish in the separator panel immediately ahead of the escape chute reduces separating efficiency. Increased activity in this area, due to the confinement of the panels, appears to cause the gilling in the separator panel, reducing the total separation area of the panel by as much as 10 percent.

Based on these observations and the evaluations of the various experimental designs, a prototype shrimp separator trawl has been developed. The prototype design will employ a 60-foot (headrope length) semiballoon trawl with the V panel design separator panel. The larger size trawl will provide longer separator panels, thus increasing the area of active separation. The deeper net will also allow a more shallow separator panel attack angle near the escape chute to reduce the gilling associated with this area. Both the S_2 and the R_2 panel designs will be evaluated to determine optimum separation efficiency, but the panels will be constructed from No. 24 twine knotless webbing to alleviate problems associated with knots separating on rectangular meshes and to increase the overall strength of the separator panel. The escape chute will be shortened and the exit opening slightly enlarged to prevent the clogging problems associated with gilled fish. Additional secondary separation techniques will be investigated to achieve adequate separation of problem species. The prototype selective shrimp trawl design will be intensively evaluated to find the best trawl for demonstrating to the fishing industries during their commercial fishery operations.

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U.S. PROCESSED FISHERY PRODUCTS VALUED AT $2.7 BILLION IN 1975

Fresh, frozen, canned, cured, and industrially processed fishery products in the United States, American Samoa, and Puerto Rico in 1975 were worth $2.7 billion, according to the Department of Commerce's National Oceanic and Atmospheric Administration. "Processed Fishery Products, Annual Summary 1975," compiled by NOAA's National Marine Fisheries Service, reflects that the value of the 1975 total output declined nearly 4 percent compared with 1974.

Fresh and frozen items accounted for 49.3 percent of the total value; canned, 40.4 percent; cured, 3.8 percent; and industrial, 6.5 percent. Canned tuna, produced from domestic and imported raw tuna, was the leading canned product in 1975. A total of 3,606 wholesaling and processing establishments reported selling or processing fishery items in 1975 compared with 3,534 in 1974. In 1975, fishery products were processed by 1,700 firms, a decline from 1974 of 38 firms.

Peak monthly employment for all firms in 1975 was 92,310 compared with 92,118 in 1974. Average monthly employment was 71,006 in 1975 compared with 70,750 in 1974. Peak monthly employment in the processing segment of the industry was 78,983 in 1975 and 80,666 in 1974. Average monthly employment was 60,281 in 1975 compared with 61,114 in 1974.

Pacific Coast states accounted for $839.6 million, 31.6 percent of the total value of all processed fishery products. Gulf Coast states ranked second with $418.2 million, 15.7 percent, and New England states ranked third with $391.7 million, 14.8 percent.

California was the leading state for processed fishery products with $472.3 million, followed by Puerto Rico with $304.3 million. Canned tuna was by far the most important fishery product produced in California and Puerto Rico.

The 1975 production of fresh and frozen processed products, mainly fillets, steaks, fish sticks and portions, and breaded shrimp, was $1,308.5 million compared with $1,128.8 million in 1974. The pack of canned fishery products in the United States, American Samoa, and Puerto Rico was 49.0 million standard cases (1.4 billion pounds), valued at $1,071.9 million by the canning companies. In the total were 36.8 million standard cases valued at $919.7 million for human consumption, and 12.2 million standard cases valued at $152.3 million for bait and animal food.

Production of cured fishery products in 1975 was valued at $101.6 million compared with $113.7 million in 1974. The value of salted products was $43.9 million; smoked, $55.7 million; and sun-dried, $1.9 million. The value of salted and smoked fishery products declined by $5.8 and $6.6 million compared with 1974, but the value of sun-dried products increased by $228,000 in 1975.

The value of industrial fish products, including seal skins and other items processed further, was $173.4 million in 1975 compared with $207.9 million in 1974. The quantity of fish meal produced in 1975 was 290,400 tons—nearly 11,000 tons less than in 1974. The production of fish oil reached 245.7 million pounds, 3 percent more than in 1974 and the highest since 1971. Domestic production of fish solubles was 128,000 tons, down 7 percent in quantity from 137,000 tons produced in 1974.

Copies of the report, Current Fisheries Statistics No. 6903, are available from the Data Management and Statistics Division, National Marine Fisheries Service, 3300 Whitehaven St., NW., Washington, D.C. 20235.

Atlantic Ocean Study Coordinated by NOAA

A series of undersea research projects investigating the effects of ocean dumping, the habitat and abundance of selected fish and shellfish, and undersea geology were undertaken along the Atlantic Coast in mid-summer. They were coordinated by the National Oceanic and Atmospheric Administration (NOAA). Scientists from the Commerce Department agency's National Marine Fisheries Service, the Interior Department's U.S. Geological Survey, and the Environmental Protection Agency participated in the six-leg cruise.

The three-man submersible *Mermaid II,* used in conjunction with the support vessel *Eileen B,* took scientists to a maximum 1,000 foot depth to carry out their studies. The vessels are owned and operated by International Underwater Contractors of City Island, N.Y. Total cost of the six-leg cruise was $250,000, with each agency funding its share of the work. Cruise coordinator was Elliott Finkle of the Manned Undersea Science and Technology office, a part of NOAA's Office of Ocean Engineering.

NMFS scientists, headed by Richard Cooper of the Northeast Fisheries Center, Woods Hole, Mass., surveyed the geology of the Baltimore and Wilmington canyons on the first leg, and attempted to relate the bottom-dwelling animals to the kind of material that makes up the seafloor in those areas.

The second leg (ranged) from Cape Hatteras, N.C., south to waters off Georgia. Scientists from the NMFS laboratory in Beaufort, N.C., under the direction of Peter Parker, carried out an extensive assessment of fish population, identifying habitats of selected species—primarily major sportfish such as snappers, groupers, porgies, and grunts—and measuring their abundance. Reactions of the fish to the submersible were assessed by scuba divers.

U.S. Geological Survey scientists, led by David Folger of the Woods Hole, Mass., laboratory of USGS, surveyed the geology and biology of the southeast Georgia embayment on the third leg. The particular area is one where oil exploration may take place in the near future. Donald Lear of the Annapolis, Md., laboratory of the Environmental

Protection Agency led the fourth leg, investigating the effects of ocean dumping off the coasts of Delaware and Maryland, looking at bottom animals, taking samples, and observing areas affected by the dumping.

Jack Hathaway of the USGS Woods Hole laboratory was principal investigator for the fifth leg of the cruise, in the Baltimore Canyon trough and part of Georges Bank. The team examined gear left previously during a long-term study of the geology and biology of the areas. Finally, Redwood Wright of the Northeast Fisheries Center, NMFS, led the final leg to recover a current meter array lost last year at the eastern tip of Georges Bank.

Foreign Fishing Vessels Off U.S. FCZ Up In June

The number of foreign fishing and fishing support vessels sighted off U.S. coasts in June more than doubled those sighted in May, according to preliminary figures released by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service.

In June, 767 vessels were sighted as compared with 374 sighted in May, reflecting the normal increase of fishing effort by all countries during this season of the year. The June number is 203 vessels, or 21 percent, less than the record-breaking 970 vessels off our coasts in June 1976. The May 1977 total was 60 percent below the 924 vessels sighted in May 1976.

The foreign vessels were sighted off the coasts of New England, the mid-Atlantic states, Gulf of Mexico, west coast, and Alaska. The ships were from 8 nations, compared with 13 nations a year ago. The largest number of foreign fishing vessels, 621, was from Japan which had 581 vessels fishing for salmon and pollock off Alaska, 39 longline vessels fishing for tuna in the Gulf of Mexico, and 1 fishing for squid off New England and mid-Atlantic.

Included in the total for Alaska are 263 ships engaged in the salmon gillnet fishery. These ships are not required to have a permit under the 200-mile law but are issued registration permits by the State Department in compliance with the regulations of the International North Pacific Fisheries Commission.

The Soviet Union had 82 vessels, 37 fishing for hake off New England and mid-Atlantic, 26 fishing for hake off the Pacific coast, and 19 catching pollock in Alaskan waters. Canada, fishing under a reciprocal agreement with the United States, had 37 vessels, 18 fishing for haddock and cod off New England and mid-Atlantic, 16 fishing for salmon off the west coast, and 3 fishing for halibut off Alaska.

Spain had 14 vessels fishing for squid off New England and mid-Atlantic. South Korea had 5 vessels fishing for sablefish off Alaska. Poland had 5 vessels fishing for hake off the west coast. Bulgaria had two vessels fishing for hake off New England and mid-Atlantic. Taiwan had one vessel fishing for pollock off Alaska. A summary of foreign fishing vessels operating off U.S. coasts during June 1977 and June 1976 follows.

Foreign vessels sighted off the coasts in 1976 were as follows: January-420, February-510, March-435, April-560, May-924, June-970, July-842, August-543, September-514, October-452, November-258, and December-240. In 1977: January-319, February-314, March-180, April-235, May-374, and June-767.

		Number of vessels	
Area	Nations	June 1977	June 1976
New England and mid-Atlantic	Russia	37	20
	Poland	0	10
	Bulgaria	2	0
	E. Germany	0	2
	Spain	14	16
	Japan	1	6
	Italy	0	2
	S. Korea	0	1
	Ireland	0	1
	Greece	0	1
	Canada	18	0[1]
		72	59
Gulf of Mexico	Japan	39	5
	Cuba	0	31
	Panama	0	1
		39	37
West coast	Japan	0	2
	Russia	26	89
	S. Korea	0	16
	Bulgaria	0	3
	Poland	5	4
	E. Germany	0	1
	Canada	16	0[1]
		47	115
Alaska	Canada	3	0[1]
	Japan	581	616
	S. Korea	5	53
	Taiwan	1	2
	Russia	19	88
		609	759
Total		767	970

[1]Number of Canadian vessels off U.S. shores not recorded.

NMFS Seeks New Approach to Tuna Fishing Rules

The National Marine Fisheries Service, in an effort to reduce the number of porpoises killed in U.S. yellowfin tuna purse seine fishing operations, has proposed quotas of 51,930 for next year, 41,600 for 1979, and 31,140 for 1980. This year's quota is 59,050. The Commerce Department agency, in proposed regulation changes published in the Federal Register on Wednesday, 20 July, seeks not only to establish new quotas but to be able to set quotas over a 3-year period rather than year-by-year.

"These proposed changes in the regulations represent a new approach to regulation of the incidental killing of porpoise in U.S. purse seine fishing operations," says Robert W. Schoning, Director, NMFS. "We believe the changes are an improvement over the present regulations since all concerned are told what they may expect over several years and they plan accordingly. We will review the regulations constantly so that they may be adapted to take advantage of any new technology that develops."

The intent of the proposed changes to the regulations published under the Marine Mammal Protection Act of 1972, is to achieve a 50 percent reduction in the number of porpoises killed in the fishery by 1980. This proposed reduction is a straight line projection and is considered technologically possible by NMFS scientists and gear specialists as fishing gear and techniques improve. The changes set limits on individual species which will not adversely affect the status of the stocks and also con-

sider the normal historic composition of the kill. Achievement of the 50-percent reduction would require that the average rate of porpoises killed per ton of tuna caught not exceed 0.5 in 1978, and be reduced to 0.4 in 1979, and to 0.3 in 1980.

Rules and regulations would be established to permit the amendment of regulations and permits through informal rule making during the 3-year period, rather than using formal hearings by an administrative law judge each year, unless major changes were proposed. In this event, a formal hearing would be required.

Additionally, certificates of inclusion under permits to engage in yellowfin tuna purse seining operations on porpoise would be issued to vessel owners rather than to boat captains, as is done under the present regulations. The changes also propose that tunaboats be required to install a porpoise apron system—a chute-like area in the back of nets designed to permit porpoises to escape.

Public hearings on the proposed changes began 22 August in San Diego, Calif., and concluded in Washington, D.C. After a review of evidence presented during the hearing, Administrative Law Judge Frank W. Vanderheyden will make recommendations on the proposals to the Director, NMFS.

Pileggi Cited for Market News Effort

Joseph Pileggi, staff assistant to the Associate Director, National Marine Fisheries Service, NOAA, received the National Market News Association's Distinguished Service Award at its 20th annual meeting, 22-25 June in San Francisco, Calif.

With nearly 40 years in government fishery work, with a large portion in market news activities, Pileggi was honored with a plaque and a certificate, for encouragement and support for the market news reporting services.

The association is an organization of market reporters, information specialists, and analysts, whose purpose is to improve market information.

URI Starts New Fisheries Observer Training Program

The training of individuals to enforce U.S. commercial fishing regulations aboard foreign fishing vessels in the 200-mile zone will be one of several new activities the University of Rhode Island (URI) Sea Grant Program will undertake this year. Graduates of the new fisheries observer training program will be qualified to represent NOAA's National Marine Fisheries Service on foreign fishing vessels. Observers gather biological data and monitor compliance with U.S. regulations limiting foreign fishing within the 200-mile limit.

Funding for this and for a variety of other marine-oriented research, education, and advisory efforts will come from a $1,258,000 grant from the National Oceanic and Atmospheric Administration (NOAA) announced by Secretary of Commerce Juanita M. Kreps. The State of Rhode Island will provide an additional $684,000 to support the Sea Grant activities, according to Niels Rorholm, Sea Grant Program Coordinator at the University. It has received funding for marine activities from NOAA's Office of Sea Grant since 1968.

Another new activity, conducted by URI's recently created Center for Ocean Management Studies, will be promotion of effective management of marine resources, particularly those within the 200-mile limit. Conferences, workshops, and short-term research studies will be conducted, Rorholm explained.

Other projects initiated this year will be a study on improving fuel efficiency aboard fishing trawlers by changing propulsion devices, an analysis of the impact of recreational fishing, and a doctoral program in resource economics.

Continuing Sea Grant projects at URI include refining and developing aquacultural systems for salmon, developing a fast and simple method for determining seafood quality, providing technical and scientific assistance to the state's Coastal Resources Management Council, and researching the degradation of metal fiber reinforced concrete.

The new grant will also support the extension work of URI Marine Advisory Service specialists, and the operation of the URI Marine Information Center.

Planned Yellowfin Tuna Import Embargo Delayed

An embargo on the importation of yellowfin tuna caught by foreign fishermen in association with porpoise, planned earlier this year, was delayed until 1 October, the National Oceanic and Atmospheric Administration (NOAA) reports. The embargo is against imports from those countries whose regulations do not meet the U.S. standards concerning the killing of porpoises during yellowfin tuna purse seine fishing operations.

The delay follows adoption of a resolution by the Inter-American Tropical Tuna Commission (IATTC) to take steps which may lead to a reduction of the numbers of porpoises killed by its member nations while "fishing on porpoise." Robert W. Schoning, Director of NOAA's National Marine Fisheries Service, authorized the delay after members of the Commission unanimously agreed to establish an international tuna-porpoise research and observer program.

"This positive move by the IATTC is encouraging," said Schoning. "The resolution is the first significant action taken by the IATTC to actively reduce the numbers of porpoises killed by its members in the yellowfin tuna fishery." The Commission will allow nonmember nations fishing in the Commission's Yellowfin Regulatory Area to participate in the program.

Modeled after an existing observer program conducted by NOAA—a Commerce Department agency—the IATTC effort will expand the amount of information available concerning the effect upon the porpoise population of yellowfin tuna purse seine fishing. IATTC member nations—the United States, Canada, Costa Rica, Nicaragua, Panama, Japan, Mexico, and

France—will employ the technicians to serve on their own tuna boats, but the sea-going specialists will be recruited, trained, and supervised by the IATTC staff.

Data collected by the observers will be analyzed by the Commission, which will distribute an estimate of the total porpoise kill without disclosing the kill rate by vessel or country. The program will be in addition to the observer program now being conducted by the United States. Public comments received and the status of the implementation of the IATTC resolution were to be evaluated before a final decision was made regarding the possible extension of the embargo date past 7 October.

Marine Worm "Cities" Studied off New York

Underwater plateaus of mud near New York's Fire Island are worm "cities" whose residents could be regulating the effect of pollutants on the marine environment there, scientists with the National Oceanic and Atmospheric Administration (NOAA) believe.

NOAA researchers aboard the *George B. Kelez* encountered the dense concentrations of marine tube worms during a survey of the sea floor south of Long Island. The study was part of NOAA's Marine Ecosystems Analysis (MESA) project, managed by the Commerce Department agency's Environmental Research Laboratories. A major goal of MESA is to study the effect of the area's human population on the marine ecosystem of the New York Bight—the corner of the Atlantic Ocean between Long Island and the New Jersey shore.

Tube worms affect both the physical properties and chemistry of sediments which settle upon mud banks inhabited by the creatures, according to Joel O'Connor of the MESA New York Bight office at Stony Brook, N.Y. Like the earthworm, as they burrow just beneath the surface of the ocean bottom they turn over the sediments, mixing them into the upper few inches of the bottom mud. Too, they bind the sediments together, making them less subject to erosion.

Mud from the string of bays along the south shore of Long Island washes through Fire Island Inlet and settles on the sea floor. It may be "natural" mud stirred up by storms or tides, or it may come from human sources. Domestic septic tanks, polluted canals, industrial outfalls all empty into the Long Island bays. The worms could be imbedding these pollutants in the sediments. MESA researchers plan to analyze samples of the mud for pollutants, to find out.

George Freeland, a researcher at NOAA's Atlantic Oceanographic and Metërorological Laboratories in Miami, said the mud banks rise up to 8 inches (20 cm) above the otherwise smooth, sandy bottom. They are concentrated near the mouth of Fire Island Inlet, but extend up to 4 miles (7 km) to the southwest. Freeland also noted a sharp break between the edge of a mud patch and the surrounding sand: "In a space of 3 or 4 inches (7.5 to 10 cm), you go from one to the other."

Another question to be answered, Freeland said, is whether the worms are squatters or homesteaders. "We don't know whether the worms found a little mud, settled there, and accelerated the accumulation of more mud, or if they built it up themselves through feeding and elimination processes. In short, which came first, the worms or the mud?"

Such worm banks are not uncommon, according to O'Connor. The existence of the patches of mud off Fire Island had been known for some 40 years, but the actual extent and nature of the worm banks had not been realized until the NOAA survey.

The amount of mud, as well as its source, is uncertain. It ranged from 6 percent of total sediment in some areas to as much as 30 percent in one spot. Freeland hopes that divers will soon be able to descend and collect samples by hand, to find out just how much mud there is in the worm banks. Meanwhile, another MESA cruise is making additional photographic and sonar scans of the area, and collecting more sediment samples.

Aquaculture Boosts Yellow Perch Supply

Great Lakes yellow perch—long a favorite for Friday night fish fries in that region—are being grown four times faster in a Sea Grant aquaculture research project than they grow in nature. Through technology developed by the Commerce Department-supported researchers at the University of Wisconsin, the popular perch can be raised to marketable size in tanks in just 10 months. It takes perch almost 3½ years to reach this size growing in the wild, according to the scientists.

Research into yellow perch aquaculture at the University of Wisconsin began in 1973. Pollution conditions in the Great Lakes had caused the supply of yellow perch to dwindle alarmingly, creating serious problems for the commercial fishermen on the lakes as well as for the restaurant and tavern owners who were dependent upon the perch for popular Friday night fish fries. As a result of the research, an estimated 20 commercial perch fish farms have been started in Wisconsin, and at least two have marketed their first crop, university researchers who have assisted in the establishment of the private aquaculture projects said.

Much of the research carried out with perch can be applied to walleye pike, although pike take longer to grow to a marketable size, according to the scientists who have begun work with the pike. The researchers warn that perch rearing will continue to be a high risk venture until there is greater knowledge of fish handling techniques, fish diseases, water treatment systems, and the economics of aquaculture.

Future work, under grants from the National Oceanic and Atmospheric Administration's Office of Sea Grant, will concentrate primarily on genetics

and diet, the scientists reported. They also will study energy conservation methods, since energy is a key cost factor in fish farming. The scientists hope to develop a way to use solar energy to help reduce those costs.

To assist individuals interested in raising the fish, the researchers have produced a brochure answering 36 most commonly asked questions about raising fish in indoor tanks. Copies of the brochure may be obtained without charge by writing the University of Wisconsin Sea Grant Communications Office, 1800 University Avenue, Madison, WI 53706.

SOLAR ENERGY STUDIED FOR SEAFOOD INDUSTRY

The Virginia Polytechnic Institute and State University has been awarded a $70,000 Sea Grant to study energy use by the State's seafood industry and the possibility of its utilizing alternative energy sources such as solar heating. The grant from the Commerce Department's National Oceanic and Atmospheric Administration will be augmented by $47,500 from VPI&SU.

Specialists from the Blacksburg, Va., institution, along with experts from utility companies, will carry out "energy audits" at oyster and clam shucking houses and at crab and finfish processing plants to determine how much energy is required for such activities as processing, heating and cooling, and lighting. Economists also will examine the possibility of using solar energy for water and space heating, as well as for other processing operations.

Even if each of the State's seafood processors saved only $100 per year, the scientists claim, this would conservatively represent an annual saving of more than $35,000 to the Virginia seafood industry and would reduce overall energy demand.

In addition to the energy study, the grant will fund development of a business management assistance program to help stimulate seafood sales and assist processors in reducing transportation and storage costs. This year's grant will also support an education program for managers and workers employed in harvesting, processing, and marketing seafood, which could save the industry hundreds of thousands of dollars and improve the quality of seafood available to consumers.

Surf Clam Fishery Now "Conditional"

The surf clam fishery along the Atlantic Coast has been classified as a "conditional fishery," making it ineligible for some types of government financial assistance programs, according to the National Oceanic and Atmospheric Administration (NOAA).

United States landings of Atlantic surf clams, mostly in waters from New York to North Carolina, dropped sharply in 1976 because of over-harvesting and high mortality rates.

The adoption as a "conditional fishery" rules out the use of National Marine Fisheries Service (NMFS) financial programs to add more surf clam fishing vessels to the existing fleet. Funds would continue to be available, however, to assist vessel owners in the fishery to upgrade existing vessels, or to replace vessels lost or withdrawn from the fleet. Robert W. Schoning, NOAA's Director to NMFS, said the surf clam fleet is now as large as the resource can support.

One of the contributing factors that led to the decision to declare the fishery conditional was the high 1976 mortality of clams from an area that traditionally has accounted for two-thirds of domestic clam production. The loss was caused by a severe and prolonged lack of dissolved oxygen in the bottom waters of the ocean in a 3,500-square-mile area off the coast of New Jersey last summer, following development of a gigantic bloom of algae in the offshore, subsurface waters from Chesapeake Bay to Rhode Island. Decomposition of the algae bloom used up the dissolved oxygen in bottom waters, and resulted in the wholesale mortality of surf clams, and of other bottom-dwelling marine organisms.

Financial assistance programs of the Commerce Department agency help fishermen finance or refinance the cost of constructing or reconditioning fishing vessels. Under the Fishing Vessel Obligation Guarantee program, a NMFS guarantee can provide 15-year financing at reasonable interest rates for up to 75 percent of the cost of constructing or reconditioning fishing vessels.

The Capital Construction Fund program may be used to obtain deferment of Federal taxes on income derived from commercial fishing operations when such income is deposited in a special fund with the intention of using it for constructing, reconditioning, or (under limited circumstances) acquiring a commercial fishing vessel. Both of these programs will remain available for replacement or construction of vessels already operating in the fleet.

Limited Alaska Marine Mammal Take Suggested

Administrative Law Judge Malcolm P. Littlefield has recommended that the National Marine Fisheries Service and the U.S. Fish and Wildlife Service permit limited harvest of nine species of marine mammals found in Alaskan waters and that the State of Alaska be permitted to manage the animals. Six of the species are under the jurisdiction of the Department of Commerce.

Under the Marine Mammal Protection Act of 1972, the moratorium against taking marine mammals can be waived for the protected species if the stocks of marine mammals are at their optimum level, regulations for the conservation of the animals are provided, and formal rulemaking procedures are followed.

The Judge recommended that the numbers of the Commerce Department-regulated species taken annually be limited as follows: northern sea lion, 7,800; beluga whale, Cook Inlet stock, 10 and Bering-Chukchi Sea stock, 350; harbor seals, land-breeding, 8,461 and ice-breeding, 5,700; ringed seals, 20,000; ribbon seals, 500; and Pacific bearded seals, 4,000. The Judge found that an annual harvest that did not exceed these limits would maintain these stocks at a satisfactory level. The other three Alaskan species, polar bear, sea otter, and Pacific walrus, are under the jurisdic-

tion of the Department of the Interior.

Judge Littlefield also indicated that before the waiver is granted and management responsibility is returned to Alaska, the State should develop detailed regulations which incorporate sound principles of resource protection and conservation including research, enforcement, census, habitat acquisition and improvement, and public participation in the development of game regulations. A summary of the major points of the recommended decision applicable to Department of Commerce species was published in the Federal Register on 20 July.

COD, SNOW CRAB QUOTAS REACHED

The 1977 quotas were reached by July for cod that can be taken by U.S. commercial fishermen in the Gulf of Maine, and for snow crabs that can be taken by Japanese fishermen in the Bering Sea south of the Pribilof Islands, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service has announced.

The cod quota of 5,000 metric tons was established for U.S. commercial fishermen by the New England Fishery Management Council under terms of the Fishery Conservation and Management Act of 1976. Foreign fishermen are not permitted to catch or retain any of three species of fish, including cod, covered by that plan. Although fishing specifically for cod is now prohibited, incidental catches are permitted if they do not exceed 5,510 pounds or 10 percent by weight of all other fish on board the commercial vessel.

Japanese crab fishermen reached their quota of 5,600 metric tons of snow crab in the eastern Bering Sea south of the Pribilof Islands on 30 June. An additional Japanese quota of 6,900 metric tons of snow crabs that may be caught in other areas of the Bering Sea is expected to be reached by the end of this month. National Marine Fisheries Service observers have been on board Japanese processing vessels monitoring the catch, the Commerce Department agency reported. U.S. fishermen are not restricted to the amount of snow crabs they may catch in the Bering Sea.

The U.S. snow crab fishery has grown steadily in the past several years, from a catch of about 50 metric tons in 1972 to more than 10,000 metric tons in 1976. As the capability of the American fleet increases, the amount allotted to foreign countries will decrease.

Fish Retail Price Index Up 0.6 Percent in June

The retail price index, seasonally unadjusted, for fish rose again in June by 0.6 percent over May and by 13.5 percent above June 1976, according to a monthly statistical analysis by the National Marine Fisheries Service. The May index was 1.3 percent over April 1977 and 13.8 percent above May 1976.

Of the 17 frozen and canned fishery products surveyed in June by the Commerce Department agency, an element of the National Oceanic and Atmospheric Administration, 7 increased, 9 declined, and 1 was unchanged. Prices increased for cod, ocean perch, whiting, and turbot fillets; canned red salmon; canned Norway sardines; and fish portions.

On the other hand, prices decreased for flounder fillets, halibut steak, king crab meat, canned solid white and chunk light tuna, canned pink salmon, canned Maine sardines, fish sticks, and breaded shrimp. The price for haddock fillets remained the same.

Meat prices rose 0.9 percent in June from May on the strength of higher pork prices. Retail poultry prices in June declined 3.6 percent from May. When compared to a year earlier levels, the price for meat increased 1.9 percent and for poultry increased 1.2 percent.

Ten cities are surveyed every month by NMFS officials who report prices of selected items of fish, meat, and poultry items for "Operation Fish Watch." They visit three different chain stores in each city and check the prices for the same representative brand names and types of products to determine any changes from the previous month.

The cities surveyed are: Atlanta, Ga.; Boston, Mass.; Little Rock, Ark.; Galveston, Tex.; San Francisco and Los Angeles, Calif.; Pascagoula, Miss.; St. Petersburg, Fla.; Seattle, Wash.; and Washington, D.C.

SHRIMP CULTURE GRANT AWARDED

A Massachusetts-based firm, Groton BioIndustries Development Company[1], has received a $29,900 grant from the National Oceanic and Atmospheric Administration's Office of Sea Grant to investigate commercial shrimp aquaculture. The Commerce Department agency grant will be augmented by $34,300 in matching funds from Groton BioIndustries and Maricultura, S.A., a Costa Rican aquaculture company associated with the U.S. firm.

Aquaculture scientists will spend a year at a shrimp farm in Central America, gathering biological data from "growout" ponds—small, earth-bottomed enclosures used for raising shrimp from the early larval stage to market size. Extensive growout habitats are by design similar to natural shrimp habitats, according to Harold H. Webber, president of Groton BioIndustries. Advocates of extensive aquaculture believe that shrimp will grow under artificial conditions if enough of the natural conditions are duplicated.

"The problem," said Webber, "is in knowing what to do if the artificial system fails or if better than natural performance is wanted. Without a theoretical understanding of how a system works, the extensive culturist can do little but try to duplicate the natural environment."

One problem that can be particularly vexing to shrimp farmers is the sometimes wide variation in productivity between neighboring growout ponds, even when the species of shrimp, feed, sunlight, and other factors are apparently identical. The researchers hope to use their findings to create an ecological model of a pond to determine how to increase productivity most economically.

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Nova Scotia Studies Joint Fishery Ventures

Nova Scotia's Fisheries Minister, Dan Reid, led a 10-member fisheries trade delegation in June 1977 to West Germany, Poland, Czechoslovakia, the Soviet Union, and Finland to explore the possibilities of cooperative fishery arrangements with these countries. Nova Scotia's Department of Fisheries has called the trade mission a great success with regard to its two main aims: 1) assessing the degree of interest in cooperative fishing arrangements, and 2) examining the market potential for Canadian fishery exports to Europe.

Reid claims that cooperative fishing ventures are currently the only way for Nova Scotia to take advantage of the opportunities created by the extension of the 200-mile fisheries jurisdiction until Canada develops further its own harvesting and processing capacity. On the other hand, Federal Fisheries Minister Romeo LeBlanc viewed the activities of the trade mission with something less than unbridled enthusiasm. Noting that very few cooperative fishery arrangements have been approved so far, LeBlanc stressed that the first priority of the Government's fisheries policy should remain the recovery of stocks from years of overfishing by both domestic and foreign fishermen. He also said that he doubted that joint fishery ventures between Nova Scotia and European countries would be truly beneficial to the Province. (Source: IFR-77/125.)

According to the NMFS Office of International Fisheries, LeBlanc's policy of discouraging joint fishery ventures appears to be running into increasing resistance, especially in Canada's Atlantic provinces. Not long ago Newfoundland initiated a joint venture arrangement with the West Germans involving an allocation of 6,000 t of northern cod, to be caught off the coasts of Labrador and northern Newfoundland, which the West German trawlers would land in Canadian ports for processing before transporting them back to Europe.

In the case of Nova Scotia, there is no detailed information on the specific grounds and species which would be involved in the porposed joint ventures. The Federal Government's overall fisheries policy emphasizes conservation of depleted resources even more in the waters off Nova Scotia and in the Gulf of St. Lawrence than off Newfoundland, especially in Nova Scotia's northern shelf, and, for this reason, LeBlanc's negative reaction to the Nova Scotian trade mission is not surprising.

The dangers of joint ventures, which are more evident to the Federal Government than to the Provincial Fishery Ministries and to the local fishery spokesmen, are twofold: 1) the possibility that the joint ventures would invalidate the Government's efforts to reduce dramatically foreign fishing in Canadian waters and delay, or even prevent, the rebuilding of depleted fishery stocks, and 2) the threat that, if the joint ventures are not set up carefully enough, it could be difficult to terminate them when they are no longer necessary.

This last consideration is crucial because, although everyone seems to agree that Canada will possess, in the distant future, the capacity to increase considerably its fisheries catch, there are sharp differences of opinion over priorities in the interim, or transitional, period. The Federal Government has placed strong emphasis on a stabilization of the fishing effort by greatly reducing foreign fishing to enable the depleted stocks to recover, while some people in the provinces feel that, with the introduction of the 200-mile zone, the problem of foreign fishing has been solved and that Canada should seek to take advantage of its jurisdiction over marine resources as quickly as possible. Since Canada's fishing fleet still consists, for the most part, of small- and medium-sized vessels, the easiest and least expensive way to increase harvesting capacity over the short term is through joint ventures with foreign companies.

The willingness of fishery officials in Nova Scotia to explore opportunities for joint fishery ventures with Europeans is all the more understandable when one considers the significance of the fishing industry in the economy of that Province. The fishing industry employs directly about 16,000 people and in 1975 contributed 6.6 percent of the total net value of the province's output. Even more important is the fact that Nova Scotian fishermen in 1975 landed 35 percent of Canada's total fisheries catch, assuming first place which was previously held by British Columbia. In 1976, Nova Scotia's fishery landings totaled 353,000 t, a decline of less than 1 percent from 1975.

Fishery officials in Canada's Atlantic provinces are extremely enthusiastic about the future of Nova Scotia's fishing industry. At a conference dealing with Canada and the 200-mile zone held at Mount Allison University in early March 1977, John Marsters, Director of Industrial Development for Nova Scotia's Fisheries Department, said that he expected Nova Scotia's fisheries catch to triple by 1985, reaching 900,000 t or more. At the same conference, H.D. Pyke, a former member of the International Commission for the Northwest Atlantic Fisheries (ICNAF) and a Canadian representative at the United Nations Law of the Sea Conference, stated that regulations designed to encourage joint ventures between Canadians and foreign fishing fleets should be enacted immediately. According to Pyke, joint fishery ventures would be a means of solving the basic problem in Canada's Atlantic coast fishing industry, namely, a lack of adequate investment capital.

Several other persons have supported the point of view that, since Canada now has control over its fishery resources, steps must be taken immediately to modernize the industry's harvesting and processing capacity. A common argument is that since Canada already imports most of its fishing gear, vessel engines, and electronic equipment from Europe, joint ventures would be little more than a means of importing large freezer trawlers as well. Reid told *World Fishing* in April, for example, that the Canadians ". . .

don't have . . . factory trawlers . . . that European nations have and we're very much looking forward to getting into that game."

It is still not entirely clear what, if anything, will come out of Nova Scotia's trade mission to Europe. In a more basic sense, it is not at all certain what Canada's policy toward joint ventures in the fishing industry will be. In spite of the evident differences of opinion between the Federal Government and the provinces over short-term priorities in fisheries policy, it appears that both have second thoughts on the question of joint fishery ventures. LeBlanc, who is basically opposed to them, admits that, if properly controlled, joint ventures could be useful tools for gathering information and exploring new fisheries. On the other hand, those in favor of cooperative arrangements with foreign fishing companies concede that Canada must proceed carefully. Pyke, for instance, stresses that in any joint fishery venture the foreign share of ownership should be something less than 49 percent. Reid, who led the Nova Scotian delegation to Europe, added in his interview with *World Fishing* that he would encourage foreign investment in fish processing plants and freezer trawlers on the condition that a percentage of the profits be reinvested in the Canadian fishing enterprises rather than repatriated.

Nova Scotia Ponders Swordfishery Opening

Nova Scotian fishery officials have been active in recent months trying to win the approval of the Federal Government in Ottawa for a reopening of the provincial swordfishery. According to press reports, Nova Scotia's Minister of Fisheries, Dan Reid, who is a physician, has persuaded Ottawa to support the marketing of swordfish in packages carrying warnings that continuous and heavy consumption could be harmful to one's health.

The Provincial Deputy Minister of Fisheries, John Mullally, has also indicated that Nova Scotian fishermen are irked by the presence of U.S. fishermen fishing for swordfish off the coast of Canada. More recently, Mullally has stated that he expects the Canadian Government to decide on whether to permit a reopening of the swordfishery by the end of the summer.

Among health officials in the United States and Canada, the major issue is the hazard resulting from the high mercury content of swordfish meat. In 1970, the U.S. Food and Drug Administration and Canada's Food and Drug Department prohibited interstate and interprovincial marketing of swordfish, but in the United States, where individual states have a certain autonomy in health matters, some states (Massachusetts, Maine, New York, and New Hampshire) have allowed their own fishermen to land and market swordfish.

On the Canadian side, C. M. Blackwood, Director General of the Industry Services Directorate in the Fisheries and Environment Department, has stated that he was optimistic that his Government would soon approve the reopening of the swordfishery and mentioned that efforts had been made to win the permission of U.S. health authorities for Canadian exports of swordfish to the United States.

Attempts to raise the issue of reopening the Canadian swordfishery began at least as early as the end of 1974 when Fisheries Minister Romeo LeBlanc was questioned in Parliament about the possibility of reestablishing the swordfishery and was urged to begin talks with U.S. officials on a resumption of swordfish exports to the United States. In 1975, food technologists in Nova Scotia tried various means of lowering the mercury content of swordfish products to an acceptable level, or below 0.5 ppm.

One method was the production of a fish spread consisting of one part swordfish and three parts silver hake, while further experiments were planned for the use of swordfish meat in other products, for example, fish sausage. The major obstacle to commercial development now appears to be the high cost of fishing for swordfish rather than the health hazards caused by mercury contamination. (Sources: U.S. Consulate General Halifax; U.S. Embassy, Ottawa; "Report of the Department of Fisheries " (Novia Scotia); IFR-77/131.)

Canadian Fish Vessel Subsidies Tightened

Federal subsidies for construction and changeover of fishing craft will be more selective in 1977-78 and will emphasize helping owners of older vessels, Roméo LeBlanc, Minister of Fisheries and the Environment, has announced.

This year's $2.6 million program will subsidize replacement of only the oldest vessels in three fleet sectors: 1) Atlantic region vessels 30-45 feet overall length and 10 or more years old. (A high proportion of these are lobster boats and groundfish boats.) 2) Atlantic region vessels of 60-65 feet overall length and 16 or more years old. (This part of the program will apply particularly to the Gulf of St. Lawrence, where this fleet sector is older than elsewhere and has recently faced difficult times. Available funds permit construction subsidies for no more than eight vessels of this class, and will be allocated to replace six Gulf-based boats of the bordering provinces and two based outside the Gulf.) 3) In Ontario and the prairie provinces, vessels 16-45 feet overall length and 10 or more years old. (The minimum size is lowered from the previous 20 feet.)

"We have long discontinued the scatter-gun approach to boat subsidies," LeBlanc said. "Our funds are limited, especially in view of the amount we have spent on emergency assistance to many fisheries where fleet build-up accompanied stock declines. Now we concentrate available boat-building money where it will do the most good."

The Department of Fisheries and the Environment (DFE) handles subsidies only for vessels up to 75 feet; these subsidies assist conversion and modification of vessels as well as construction. The Department of Industry, Trade, and Commerce deals with subsidies for larger vessels.

Adjustments to the DFE program follow an analysis of the smaller-vessel fleet's age and adequacy. For most fish-

eries, this fleet has more than enough capacity. On the Pacific coast in particular, construction subsidies have already stopped entirely. The Federal Government's first intention is, by good use of the 200-mile limit and by other measures, to help the existing fleet make a profit.

Of the $2.6 million in this year's program, vessels approved for assistance last year but uncompleted at the beginning of the new fiscal year will take a carry-over commitment of $650,000. For subsidies from the remaining funds, major conditions are listed below.

For construction of replacement vessels (35 percent subsidy; available funds $1.6 million), the proposed vessel must be: 1) no less than 60, no more than 65 feet, or 2) no less than 30, no more than 45 feet, or 3) in the freshwater fisheries, no less than 16, no more than 45 feet overall. The vessel plans and specifications must meet the requirements of the Department of Transport and the DFE. If the vessel is intended for use in a limited-entry fishery (such as salmon, lobster, herring (except gill-net), snow crab, scallops), it must also be employed in at least one open fishery. The vessel must be intended to replace an existing vessel of the minimum ages noted above, or to replace a total loss. The application for subsidy must be made and approved before construction of the vessel starts. The vessel must belong to a Canadian citizen or corporation. And, the vessel must be built in Canada.

For conversion or modification (available funds $310,000), eligibility is determined by a set of conditions much like the above; these can, however, change as circumstances in the various fisheries change.

CANADA SUBSIDIZES SALTFISH INDUSTRY

A $400,000 program to support the price of this year's trap-caught small codfish sold by fishermen for salting, has been announced by Fisheries Minister Roméo LeBlanc. The program, funded under the Fisheries Prices Support Act, applies to codfish landed in Newfoundland or Quebec's Lower North Shore within the purchasing area of the Canadian Saltfish Corporation.

The need for the federal government's action has arisen due to the fact that this year the price for most codfish to be salted (i.e., those 16-24 inches long) has dropped by 2 cents. On the other hand, the price of cod for processing as fresh and frozen products has risen by more than 2 cents to record levels. Last year the prices for both salt and fresh and frozen categories were at competitive levels.

Faced with this situation, processors of salt cod encountered a season of drastically reduced production, with loss of the only alternative market to fishermen and loss of employment in dependent communities. To help maintain the 1976 price level, the government, through the Fisheries Prices Support Board, began making deficiency payments at the rate of 2 cents per pound on small trap-caught codfish sold by Newfoundland and Quebec Lower North Shore fishermen to processors of cured fish. Payments were to be made to fishermen through the Canadian Saltfish Corporation.

Krill Work Reported By Germany and Chile

The Federal Republic of Germany has invested nearly $5 million in two vessels, the *Walter Herwig* and the *Weser*, for krill exploration in the Antarctic, according to a report in *Industria Conserva*. These vessels have reportedly caught up to 30 tons (t) of krill per hour. European scientists do not agree on the abundance of this species in the Antarctic. Estimates of the maximum sustainable yield range from 60 to 600 million t. The mission of the two German vessels is to determine the abundance, population dynamics, and the best method of catching krill.

Commercial processing of krill remains a problem. Soviet scientists have tried to solve the problem by producing an edible paste. However, their efforts have not been entirely successful. German experts have been experimenting with a machine to make a protein juice. The ideal solution reportedly would be a technique for peeling krill without mashing it so its meat could be used. This has not yet happened.

The Government of Chile received from the Director of the Institute of Fishery Conservation a program for krill resource research 2 years ago. Following this, two research expeditions have been conducted: by PAM *Valparaiso* (15 Jan.-15 Apr. 1975); and by PAM *Arosa Septimo* (28 Apr.-22 June 1976). These expeditions, using technology developed by Chilean scientists, were reportedly quite successful. Their findings are summarized below.

1) In the 50,000 square miles searched, a great abundance of krill is easily accessible for fishing using available gear and methods.

2) Experimental fishing brought an average krill catch of 10 t per hour, with some catches ranging up to 30 t per hour.

3) Good results were achieved using mechanized methods of peeling the krill tails, both on board and ashore.

4) The process of obtaining krill meat (pulp) yielded 43 percent (of the ex-vessel weight of krill). The pulp can be used for minced-type products, such as croquettes and fish sticks.

5) A paste has been obtained which can be used as raw material for products such as spreads, cheeses, and soups of high nutritional value. Both the pulp as well as the paste can be used to produce a great variety of food products for the development of diets and meat substitutes of consumers.

6) Krill waste products present a basis for research in fish meal and powder production for animal feed.

Russia, Angola Sign Fisheries Protocol

A delegation from the People's Republic of Angola, headed by the Minister of Fisheries Victor de Carvalho, arrived in the Soviet Union on an official visit earlier this year, according to a report in *Vodnyi Transport*. The delegation visited the fishery enterprises of Leningrad, Tallin, Riga, Kaliningrad, and Moscow.

On 26 March a protocol was signed during the first session of a joint

Soviet-Angolan commission on fishery cooperation. The Soviet Union will aid in developing the fishing industry of Angola, in conducting scientific research, and in preparing qualified national specialists. Both sides agreed that the workers of the Moscow Fish Processing Combine will cooperate with the workers of the Vivilar fish combine in Luanda.

V. Lipanov, head of the Directorate of Commercial Fisheries of the USSR Ministry of Fisheries, stated that the waters off Angola are abundant in fish, but that today half of the commercial fleet of the Republic is not operating, and specialists are lacking. Soviet specialists will be sent to work on vessels, and at enterprises and institutes. Angolan personnel will be trained both in Angola and in the Soviet Union. The Soviet Union will continue to aid the People's Republic of Angola in restoring the fishing industry.

Poland's 1976 Fish Catch Off U.S. West Coast Drops

Polish fishermen caught 25,138 metric tons (t) of fish off the U.S. Pacific coast from June through October 1976, a considerable reduction from the 53,003 t caught in 1975. The Polish fishing area included waters off Washington, Oregon, and California; no Polish vessels were reported fishing off Alaska (see map, right).

The Polish fleet operated until 1 January 1977 in these waters under the June 1975 U.S.-Polish Bilateral Agreement on Fisheries in the Northeastern Pacific. That Agreement prohibited the catching of Pacific halibut, Pacific herring, Pacific ocean perch, and certain other rockfishes, and for 1976 reduced the 1975 hake quota of 42,600 t to 26,000 t, or by 39 percent. The Agreement also prohibited the Poles from fishing off the U.S. Pacific coast from 1 January to 31 May and from 1 November to 31 December. The Polish and the United States Governments on 2 August 1976 signed a Governing International Fisheries Agreement (GIFA) which now regulates Polish fishing within the U.S. 200-mile fisheries jurisdiction.

Pacific hake and jack mackerel were the target species, with hake accounting for more than 94 percent of the total Polish catch (Table 1). Pacific rockfishes were caught incidentally. The largest catch occurred in August when 8,248 t of hake were caught (Table 2).

Of the total 1976 catch, 80 percent was taken from the waters off the Pacific Northwest (Washington-Oregon coasts). The largest catch off the California coast, 3,564 t of hake, was reported in the Eureka region, which is comprised of northern California and part of southern Oregon. Considerably smaller catches were reported for the southern California coast (Table 3).

The number of Polish vessels permitted by the 1975 Agreement to fish off the U.S. Pacific coast was limited to a maximum of 11 vessels at any one time. The Polish fleet consisted of four stern factory trawlers when it began to fish in June 1976 off the California coast. In late June the fleet moved northward to fish off the Pacific Northwest (the area referred to as "Columbia" in Figure 1). By July, five Polish stern trawlers were reported fishing for hake off California and a sixth trawler joined the fleet by the end of the month.

In August, the Polish fleet consisted of seven stern trawlers, one processing and transport vessel, and a cargo vessel of French registry under charter to the Polish government. A cargo vessel of Danish registry, also under Polish charter, arrived in September to accept the Polish catch (mostly frozen) for delivery to Poland.

The Polish fleet fished off the Pacific Northwest in August and September, except for a brief period of fishing off British Columbia. The fleet departed the fishing grounds off the United States on 30 September. According to surveillance reports compiled by the National Marine Fisheries Service (NMFS) and statistics reports submitted by the Poles, the fleet spent a total of 608 vessel days on the U.S. fishing grounds from June through October. The Polish fleet was on the coastal fishing grounds 601 vessel days from June through September, and was located at a considerable distance from shore for 7 days during October. The average catch rate per vessel per fishing day was 41.4 t.

Polish fishing off the U.S. Pacific coast began in 1973, when a small

Table 1.—Polish fisheries catch off the U.S. Pacific coast in 1976.

Species	Catch t	Catch %
Pacific hake	23,664	94.2
Jack mackerel	785	3.2
Rockfishes	427	1.6
Unspecified	262	1.0
Total	25,138	100.0

Table 2.—Polish hake catch by month, June-October 1976.

Month	Catch (t)
June	3,262
July	5,430
Aug.	8,248
Sept.	5,802
Oct.	922

Table 3.—Polish fisheries catch in metric tons off the U.S. Pacific coast, by species and fishing area, 1976.

Area	Pacific hake	Mackerel	Rockfishes	Unspecified	Total
Pacific Northwest					
Columbia	19,002	651	247	178	20,078
California					
Eureka	3,564	94	157	47	3,862
Monterey	1,070	35	23	35	1,163
Conception	28	5	0	2	35
Calif., total:	4,662	134	180	84	5,060
Grand Total	23,664	785	427	262	25,138

Table 4.—Polish fisheries catch in metric tons off the U.S. Pacific coast by fishing region, 1973-76.

Area	1973	1974	1975	1976	1973-76
Alaska	433	88	2,132	—	2,653
Pacific Northwest	2,000	38,576	11,950	20,078	64,476
Calif.	—	5,987	38,921	5,060	44,908
Total	2,433	44,651	53,003	25,138	112,037

exploratory fleet of three trawlers caught over 2,400 t in a few weeks. This exploratory research indicated the size of the resource and encouraged the Polish fishermen to return with many more vessels in 1974 when their catch amounted to more than 44,000 t. The Polish fishery expanded further in 1975, when 53,000 t were caught, and no doubt would have continued to grow had not a U.S.-Polish bilateral agreement been signed in June 1975 reducing the 1976 catch by 50 percent (Table 4).

The 1976 Polish fishery off the U.S. Pacific coast is limited by the Agreement to 26,000 t of hake or 936 vessel days, whichever occurs first. Polish catch and vessel day estimates are produced through the combined efforts of NMFS biologists, NMFS enforcement staff, the Coast Guard, and NMFS observers aboard Polish vessels, all of whom verify Polish reports and catch data. This reporting is coordinated by the Seattle, Wash., based Northwest and Alaska Fisheries Center of the NMFS.

The Director of the Northwest and Alaska Fisheries Center receives monthly telegrams from the Director of the Morski Instytut Rybacki (Polish Marine Fishery Research Institute) in Gdynia, providing preliminary Polish catches off the U.S. Pacific coast by species and by fishing area. This data is available approximately 40 days after the end of the fishing month. (Similar Soviet fisheries catch data is reported to the Northwest and Alaska Fisheries Center 70 days after the reported month.)

On 22 September, the Regional Director of the NMFS notified the Polish Fleet Commander, S. Bujniewicz, that the Polish hake quota would most likely be fulfilled by 30 September, at which time the Poles would be expected to leave the fishing grounds. The Poles, however, claimed to have caught less than the NMFS estimate and requested permission to remain on the fishing grounds until 15 October. Permission was refused and the Regional Director suggested a review of the Polish log books. Faced with a review of the logs of all of his vessels, Bujniewicz acquiesced to the initial demand, and, by 1 October, the fleet had departed. The Polish fishing fleet then moved north to waters off British Columbia where the Canadians had granted Poland a hake quota of 14,000 t.

On 14 October, the Polish Fleet Commander sent a telegram to the Regional Director requesting permission to fish for jack mackerel near Heceta Bank, an area approximately 30 miles off the coast of central Oregon. In reply, the Regional Director cited a section of the Bilateral Agreement which prohibits the Poles from fishing east of long. 125°40′W, and, therefore, only allows them to fish approximately 32 miles west of Heceta Bank. On 11 November, the Polish Fleet Commander repeated his request and the Regional Director again cited the Bilateral Agreement which also prohibits the Poles from fishing in that area after 1 November.

ICSEAF Examines Extra Fishing Rule Proposals

The Second Special Meeting of the International Commission for the Southeast Atlantic Fisheries (ICSEAF) which is headquartered in Madrid, was held in Malaga, Spain, 1-16 December 1976. Normally the Commission would have met in 1977.

This special meeting was called to examine additional limitations in the fishing of certain ICSEAF Convention Area species. The meetings were attended by more than 75 scientists, industry leaders, and government officials from the 14 member states, which are: Angola, Belgium[1], Bulgaria, Cuba, East Germany, France, Israel, Italy, Japan, Poland, Portugal, the Republic of South Africa, Spain, and the Soviet Union. Three nations (South Korea (ROK), the United States, and West Germany[2]) and five international bodies (FAO, ICCAT, The Joint Commission for Sea Fisheries of the Socialist Countries, the International Council for the Exploration of the Sea (ICES), and the Intergovernmental Oceanographic Commission (IOC)) were present as observers.

The ICSEAF Convention Area, established in Rome in 1969, covers the waters around southern Africa south of the Congo River on the Atlantic Ocean, to north of the Zambezi River in the Indian Ocean (see map). The area touches the shores of Angola, Namibia, the Republic of South Africa, and Mozambique. Namibia and Mozambique are not ICSEAF members.

[1]Expected to leave ICSEAF at end of meeting.
[2]Expected to join ICSEAF soon.

Preliminary ICSEAF catch statistics report that 2.6 million metric tons (t) of fish were harvested by more than 15 nations fishing in this convention area in 1975 (Table 1).

ICSEAF also considered the status of other species during their deliberations in Malaga. It was recommended that kingklip, *Genypterus capensis*, which

Table 1.—ICSEAF convention area total fisheries catch by country, 1975, in thousands of metric tons.

Country	Quantity	Country	Quantity
Angola	185.1	Portugal	8.7
Bulgaria	31.6	St. Helena[1]	0.2
Cuba	44.6	South	
France	0.4	Africa	1,395.8
Ghana[1]	35.7	Spain	200.3
Israel	6.4	USSR	420.7
Italy	7.0	Others[2]	14.5
Japan	131.5		
Poland	76.2	Total	2,558.7

[1]Not ICSEAF members.
[2]Includes Mozambique and Zaire.
Source, ICSEAF, "Catch and Fishing Effort Statistics for 1975."

Table 2.—ICSEAF convention area catch of Cape and Benguela hake, 1970-75, in thousands of metric tons.

Year	Quantity	Year	Quantity
1970	762.0	1973	892.7
1971	798.3	1974	726.0
1972	1,111.4	1975	627.2

Source: FAO, "Yearbook of Fishery Statistics, 1975."

Table 3.—ICSEAF convention area total hake catch, by country, 1975, in metric tons.

Country	Quantity	Country	Quantity
Angola	100	Portugal	6,985
Bulgaria	9,802	South	
Cuba	29,630	Africa	113,083
Ghana	925	Spain	168,580
Israel	5,900	USSR	209,125
Italy	6,500	Others	500
Japan	52,101		
Poland	37,126	Total[1]	640,357

[1] Includes 498 t of *M. polli*, 168,065 t of *M. capensis*, 216,093 t of *M. paradoxus*, and 1,164 t of unidentified hake (*M.* spp.)
Source: ICSEAF, "Catch and Fishing Effort Statistics for 1975."

has not been fully harvested, be considered suitable for increased development along with Cunene and Cape horse mackerels, *Trachurus trachurus*, and Sardinella, *Sardinella* spp. The SAC also reported that stocks of anchovy, *Engraulis* spp, and South African pilchard, *Sardinops ocellata*, were being fished at near-optimum levels and that no increase in the fishing effort should be allowed. Finally, because of an 85 percent decline in catches of large-eyed dentex, *Dentex macrophthalmus*, from 555,400 t in 1968 to 8,300 t in 1974, it was recommended that fishing for this species, and for panga, *Pterogymnus laniarus*, be limited to 9,000 t per year each.

The species attracting the greatest attention at the Malaga ICSEAF meeting were Benguela hake, *Merluccius polli*, and Cape hake, *M. capensis* and *M. paradoxus*. In 1969, when ICSEAF was formally established, only nine countries fished for hake off southern Africa; the catch had increased from 111,100 t in 1960 to 676,000 t in 1969. By 1971, when the Convention went into effect, the catch of hake had increased to 798,300 t. Subsequently the catch rose to 1,111,400 t in 1972 before declining to an estimated 627,000 t in 1975 (Table 2). The estimated hake catch by country for 1975 is given in Table 3. The largest catch of over 200,000 t (32 percent of the total) was taken by the USSR. Spain took 168,000 t, or 26 percent of the total.

The large decrease in hake landings between 1972 and 1975 affected all nations fishing for that species in the ICSEAF Convention Area, but it particularly affected the Soviet Union. The USSR hake catch of 656,000 t in 1972 declined to 209,000 t in 1975. In 1974-75 the USSR, concerned about the decline in hake catches, switched to fishing horse mackerel to reduce fishing effort on the hake resource.

The precipitous decrease in the total hake catch since the 1972 record catch of 1.1 million t to the 640,000 t caught in 1975 has naturally spurred the ICSEAF Commission to take steps to manage this valuable fishery resource. One of the first steps taken in December 1974 by the newly formed Commission was the adoption of a minimum mesh size of 110 mm in the hake fishery. The second step was the establishment of a joint inspection and enforcement program which came into force on 1 July 1975. Since that time over 160 inspections have been carried out by South African inspectors, and other nations are carrying out similar inspection on board their own vessels. Few infractions of the minimum mesh size regulation have been reported. In 1975, at the ICSEAF meeting in Madrid, the Commission accepted the recommendations of the Scientific Advisory Council (SAC) stating that hake catches should not exceed a maximum sustainable yield of 950,000 t annually. In 1976, the SAC recommended that the total allowable catch be reduced to between 630,000 t and 700,000 t annually. South Africa also proposed the establishment of a quota system for hake.

Mozambique Gets National Fishery Marketing Agency

The Government of Mozambique has established PESCOM (Empresa Nacional de Comercialização de Produtos Pesqueiros), a state agency for marketing Mozambican fishery products. The enterprise, to be controlled by the Ministry of Industry and Commerce, will be headquartered in Maputo (formerly Loureno Marques), and is to have branches elsewhere in the country.

PESCOM will have a declared capital of 100 million escudos (US$3.3 million), entirely subscribed by the Mozambique Government. The capital can be increased by joint decision of the Ministry of Industry and Commerce and the Ministry of Finance.

PESCOM's main objectives are: 1) to buy, store, distribute, promote, and sell all Mozambique fishery products, processed or not; and 2) to import and export all fishery products, processed or not.

PESCOM will be managed and controlled by the following five groups: General Council, Executive Committee, General Assembly of Workers, Audit Committee, and Executive Council.

The General Council (Conselho Geral) will represent the Government's interest in the firm. Its Chairman will be designated by the Minister of Industry and Commerce. Four representatives will be chosen, one each from the National Directorate of Fisheries, the National Directorate of Foreign Commerce, the National Directorate of Domestic Commerce, and the Ministry of Finance.

An Executive Committee (Direcção) will direct the management operations. It will be made up of the Director-General and four Deputy Directors

(Administrative, Technical, Commercial, and Labor). The Director General and three Deputy Directors will be appointed by the Minister of Industry and Commerce (who may also increase the number of Deputy Directors). The Director for Labor will be elected by the General Assembly of Workers.

The General Assembly of Workers (Assembléia dos Trabalhadores), as the representative of labor, will have the dual function of participating in the control of PESCOM and of working in close cooperation with the Executive Committee and the Executive Council.

The Audit Committee (Comissão de Fiscalização de Contas) will consist of three members to be appointed by joint decision of the Ministers of Industry and Commerce and of Finance.

The Executive Council (Conselho de Direcção), comprised of the Executive Committee, PESCOM department chiefs, and FRELIMO Party representatives, will coordinate PESCOM's activities.

PESCOM must first of all prepare an operations investment plan for the next several years. In the future, PESCOM will prepare annual operations plans and budgets. The enterprise is exempt from income tax.

According to the NMFS Office of International Fisheries, Mozambique press reports indicate that PESCOM is building a cold storage plant in the port of Maputo, which will have five units capable of storing 500 metric tons (t) of shrimp and other fish. Similar plants are planned for the ports of Beira and Quelimane, and eventually for Nacala.

Mozambique recently took delivery of eight shrimp trawlers built by the Inconav shipyard of Brazil. These vessels will reportedly operate off Beira and Angoche. Of these vessels, six are owned by the IMPESCAL company, which will now come under the control of PESCOM. IMPESCAL's fleet includes 28 vessels, making it the largest shrimp company in Mozambique. The remaining shrimp trawlers were reportedly purchased by private companies. A total of 17 more shrimp trawlers were to be delivered by Brazilian shipyards beginning in February 1977, but no information is available as to whether the deliveries have begun. The Bank of Brazil provided $38 million in financing to Inconav for the construction of vessels for both Mozambique and Angola.

Norway White Paper Says Modernize Fishing Fleet

The Norwegian Government has released a preliminary White Paper recommending the modernization of the country's fishing fleet to utilize more effectively Norway's new 200-mile fishery zone. The White Paper also delineated plans to reduce the number of Norwegian fishmeal plants, particularly those located in southern Norway.

The fleet modernization proposals would give Norwegian fishermen 10-year interest-free loans covering up to 25 percent of the cost of new vessels. During 1977, about US$4.8 million would be available for such loans. This money would be taken from the $55.3 million currently budgeted for the Norwegian fishing industry in 1977 to cover rising fuel and gear costs as well as to aid entrepreneurs to form fishing ventures. The White Paper reports the goal of replacing 50 fishing vessels each year to modernize a fleet which now consists of vessels whose average age is 20 years or older.

The White Paper also emphasized the need for Norway to adjust the capacity of its fishing fleet to the available resources. As a result, it recommended reducing the purse seiner fleet by 20 percent, the industrial trawler fleet by 24 percent, and the brisling fleet by 50 percent. The fleet reductions are projected to continue through 1980.

In addition, the White Paper proposed the modernization of Norway's 1,000 processing plants, currently employing more than 20,000 workers, by increasing automation. This recommendation has provoked widespread criticism as it presages increasing unemployment. The proposal to reduce the number of fishmeal plants from 46 to 36, particularly along the southern coast of Norway, has also caused controversy. (Source: IFR-77/128.)

According to the NMFS Office of International Fisheries, the White Paper is only a working document which was sent to various organizations for consideration and did not yet represent the official policy of the Norwegian Directorate of Fisheries. The Norwegian Parliament was expected to vote on the final proposals after the national elections in autumn 1977.

West German Herring Situation Reviewed

Statistics on West Germany's 1975 herring market reveal increasing pressure on supplies, due mainly to declining catches of the domestic long-distance fleet and West Germany's traditional major European suppliers, reports the NMFS Office of International Fisheries. Total imports show no particular trend, but imports of one category of herring products, frozen herring, have increased. Canada and the United States have a larger share of the frozen herring market and will probably increase that market in future years.

SUPPLY

The West German supply of fresh and frozen herring for human consumption was only 218,500 metric tons (t) in 1975, about 5,500 t less than in 1974 (Table 1). Landings by the Federal Republic of Germany's high-seas fishing fleet decreased from 44,700 t in 1974 to 38,700 t in 1975, while landings by the coastal and medium-range fleet showed a small increase. All domestic landings were frozen herring.

West Germany's supply of herring for human consumption in the 1972-75 period showed a heavy and increasing

Table 1.—West German supply of fresh and frozen herring, 1972-75, in metric tons.

Source	1972	1973	1974	1975
Distant-water fleet	36.8	56.4	44.7	38.7
Coastal fleet	9.0	7.2	8.2	9.7
Total domestic landings	45.8	63.6	52.9	48.4
Imports	153.1	203.7	171.2	170.1
Total supply	198.9	267.3	224.1	218.5
Imports as % of total supply	77.0	76.2	76.4	77.8

dependence on imports; domestic landings were only 22 percent of the total supply, compared with 24 percent in 1974. As recently as 1970, domestic landings were well over 100,000 t; by 1975 they had declined to under 50,000 t. Recent developments in the European herring fishery, especially the growing demand for a complete ban on herring fishing in the North Sea, leave little doubt that West Germany's domestic herring landings will continue to be depressed for some time.

EXPORTS

Exports of herring were understandably small in 1975, totalling only 9,900 t, and about 7,500 t of those went to Czechoslovakia. Prices for herring products tended to be firm in view of the tight supply situation, and, although frozen herring fillets declined on the average by 5 percent, prices for herring, with and without the head, increased 8 percent and 7 percent, respectively.

IMPORTS

West Germany's herring imports were relatively stable in 1974 and 1975, showing only a slight decline in the second year. Nevertheless, there have been some marked changes in recent years in the volume and share of different categories of herring imports. Imports of fresh herring decreased, for example, from 69,300 t in 1974 to 62,500 t in 1975. On the other hand, imports of frozen herring increased from 44,400 t to 50,500 t, or almost enough to compensate for the decreased landings of the domestic distant water fleet, which produces frozen herring exclusively.

Canada and the United States have moved into the frozen herring import market very strongly and, with 17,400 t and 7,300 t of frozen herring sales to West Germany, respectively, in 1975, they doubled their exports over 1974. Between 1970 (when frozen herring from the United States was first exported to West Germany) and 1975, U.S. sales increased from about 2,200 t to 7,300 t and showed promise of additional significant gains. These are still modest quantities, but because imports from West Germany's traditional major herring supplier, Denmark, are likely to continue to decline, market prospects for U.S. and Canadian herring exporters seem favorable in the coming years. (Source: IFR-77/132.)

Surinam Receives Two New Training Vessels

On 20 June 1977, an official of the Japanese Embassy in Caracas presented the Government of Surinam with two modern vessels to be used in training fishermen. The 73-foot vessels were built in Mexico by the South American Marine Development Company with financing provided by a $1 million grant from the Government of Japan. The grant was awarded in May 1976 and was part of a fisheries training project which Japan agreed to help fund in Surinam. Present at the ceremony were Surinam's Minister-President Henck A. Arron and top officials of the Ministry of Agriculture, Animal Husbandry, and Fisheries.

The two vessels, named the *Srefidensi I*[1] and *Srefidensi II*, carry crews of 15 and 12 fishermen, respectively. The *Srefidensi I*, a multipurpose vessel, is equipped with radar, a laboratory, and various gear. The *Srefidensi II* is designed for the shrimp fishery, currently the most important one off Surinam. Both vessels have 400 horsepower engines and freezing facilities on board.

Six Japanese fishery experts will spend 2 years in Surinam training Surinamers to operate the new boats. Several Surinamers will also travel to Japan and the Republic of Korea (ROK) for training. Funding for the training, which will cover fish catching as well as navigation and construction and repair of vessels and gear, is part of a 5-year project which, it is hoped, will be financed from Netherlands' development assistance funds. (Source: IFR-77/124.)

According to the NMFS Office of International Fisheries Japan is interested in what it generally perceived as a shrimp fishery with potential for expansion. The Japanese fishing industry is sensitive about ROK competition in distant-water fisheries. The Koreans reportedly have about 80 vessels currently deployed in the Surinam shrimp fishery and the Japanese appear worried about a possible reduction of their own position there.

The Japanese gift of the two boats was appreciated by the Government of Surinam, which is seeking to diversify its sources of economic development assistance. As a former colony of the Netherlands, Surinam largely has been dependent on that country for aid. Japan was expected to open an embassy in Paramaribo later this year or early in 1978 and it can be expected that Japanese economic and commercial interests in Surinam will expand accordingly.

[1]Srefidensi means independence.

SOVIETS REPORT AQUACULTURE WORK

In recent years fish farms have been more widely distributed in the Soviet Union, according to a report in *Vodnyi Transport*. The fish are reared from the larval stage (or fingerling stage) up to commercial weight in net ponds. The artificially reared aquatic organisms are protected from competitors and predators, their environment is protected against pollution, and they receive supplementary feeding.

The Dnepropetrovsk fish production combine has 1,300 hectares (3,211 acres) of rearing and foraging ponds. They have been built over a period of 8 years at a cost of 6 million rubles ($7,920,000). Last year, more than 2,000 t of live fish were taken from this combine. However, the group has found that raising fish in tanks was most effective. This permitted raising 2.5 t of fish in an area of 2.5 hectares (6.17 acres) of water. Only about a year was needed and the cost was reportedly six times lower. In coming years, the combine plans to establish 2,500 tank sections for raising such species as white amur, trout, silver carp, buffalo, and other species.

Fisheries Books Examine Classification, Population Dynamics, Basic Ichthyology

"Fishes of the World," by Joseph S. Nelson (xiii, 416 pp.), is a modern review of all the major fish groups at family and higher levels. Ranges of each family are given, often with maps. The number of valid genera and species for each family is also given, as are life histories and biological data. The volume contains more than 425 line drawings and has an extensive bibliography.

While largely adhering to the classical evolutionary philosophy of classification, the author also explains alternate classification schemes. Nelson is an associate professor of zoology at the University of Alberta. The volume is published by John Wiley & Sons, Inc., 605 Third Avenue, NewYork, NY 10016, and costs $24.00.

"Ichthyology," second edition (xv, 506 pp.), by Karl F. Lagler, John E. Bardach, Robert R. Miller, and Dora R. May Passino, incorporates many new advances since the first edition was published in 1962. In its 14 chapters, the book introduces the diversity of fishes and shows the position and content of the major groups, their classification, relationships and basic structure, with emphasis on living fishes. Also discussed is the comparative anatomy and physiology of the classical ten body systems and their integration into the whole fish.

Principles of genetics, evolution, systematics, ecology, and ichthyogeography are also examined. The book encompasses the broad principles of ichthyology and includes specific references with each chapter for further reading. The authors also discuss such current issues as the effects of pollution on fish and fisheries management. Also published by John Wiley & Sons, the volume costs $18.95.

"Fish Population Dynamics," edited by John Gulland, discusses both theoretical methods and practical experience in a wide range of fisheries. It incorporates 14 papers by internationally recognized authorities.

The book describes how the dynamics of fish populations can be analyzed in terms of the factors affecting their rates of growth, mortality, and reproduction, with particular emphasis on the effects of fishing. Chapters on individual species or families of fish (Pacific salmon, elasmobranchs, North Atlantic cod, North Sea plaice, clupeoids, tuna, and whales) describe how the methods have been applied to some of the major fisheries of the world.

Other chapters discuss the raw material of population dynamics, historical developments, theoretical methods and practical difficulties of tagging, analysis of data and development models, fishing effort, problems of stock and recruitment, and fish communities and aquatic ecosystems. Also published by John Wiley & Sons, the book costs $27.00.

FISH POPULATION ANALYSIS EXPLAINED

Sea Grant, Virginia Polytechnic Institute and State University, has published **"Analysis of Exploited Fish Populations"** by Robert T. Lackey. This 172-page publication summarizes the basic concepts and approaches to analyzing fish populations, particularly those under exploitation. Chapters deal with stock identification, estimating abundance, mortality concepts and estimation, growth models and determination, recruitment, predicting yield and yield models, systems analysis, and decision analysis.

Methods for evaluating the state of a population and techniques which lead to management decisions are presented. "Analysis of Exploited Fish Populations" is intended to be a bridge between introductory fisheries texts and mathematically oriented population dynamics texts. Mathematical models and derivations have been kept to a minimum while explaining the various analytical techniques. Copies may be obtained for $3.00 from Sea Grant, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Japanese Aquatic Laboratories Listed

The Council of Japanese National Marine and Inland Water Biological Stations has published a directory of the 22 aquatic biology labs affiliated with national universities. The directory lists the principal scientists, laboratory facilities, and the research programs of each lab. It also gives the names of the laboratory directors and the addresses and telephone numbers of these laboratories. A copy of the 44-page directory may be obtained from Professor Hideshi Kobayashi, Misaki Marine Biological Station, University of Tokyo, Misaki, Miura-shi, Kanagawa-ken, 238-02, Japan.

Yellow Perch Culture Risky but Feasible

Yellow perch aquaculture, a promising new food industry in the upper midwest, is the subject of a publication from the University of Wisconsin Sea Grant College Program. **"Fundamentals of Fish Farming,"** a 6-page illustrated brochure, answers 36 commonly asked questions about raising fish in indoor tanks. The questions range from "Can I raise my own fingerlings?" to "Where can I sell my fish?"

The publication concludes that it is now feasible to raise yellow perch to marketable size in tanks in just 10 months, but advises prospective fish farmers to be cautious. Perch rearing will continue to be a high risk venture, the authors caution, until there is further knowledge of fish handling techniques, fish diseases, water treatment systems, and the economics of aquaculture. Still, the UW-Madison Food Science Department scientists

succeeded in growing perch four times as fast as they grow in nature, using the technology they have developed. Economists on the project predict that there will be sufficient demand to take care of both homegrown and lake-grown perch. Free copies of the brochure are available from the U.W. Sea Grant Communications Office, 1800 University Avenue, Madison, WI 53706.

New Books Discuss Fish Farming, World Fishery Catch, Value, Products

"Farming the Edge of the Sea," (second edition), by E. S. Iversen, is a review of sea farming principles in developed nations in temperate and sub-tropical waters of the northern hemisphere. An introductory section discusses the past, present, and future of sea farming. A unit on procedures describes the use of productive areas, feeds, feeding, fertilizers, and improvement through artificial selection. Species discussed in detail include seaweeds, oysters, clams, mussels, scallops, abalones, shrimps, milkfish, yellowtail, eels, mullet, miscellaneous pondfishes, and other vertebrates and invertebrates. Finally, problems of sea farming (diseases, predation, competition, and such man-made problems as pollution and legal and security aspects) are reported.

A chapter on sea farming economics and an index are new additions. Other new material reviews laws affecting fish farming and biological aspects of certain species suitable for farming. "Farming the Edge of the Sea" is a good summary of the state of the art of fish farming in developed countries. Published by Fishing News Books, Ltd., it is available from UNIPUB, Box 433, Murray Hill Station, New York, NY 10016 at $34.00 per copy.

The 1975 fisheries statistics yearbooks of the Food and Agriculture Organization of the United Nations have also been published and are available from UNIPUB. The oft-cited two-volume compilation, **"Yearbook of Fishery Statistics, Volume 40: Catches and Landings, 1975"** and **"Volume 41: Fishery Commodities, 1975,"** provide comprehensive data on international fish catches and utilization.

FAO statistics show that the 1975 worldwide commercial harvest of fish, crustaceans, mollusks, and aquatic plants was 69.7 million metric tons, 85 percent of which came from marine waters. Pacific Ocean areas produced 51.3 percent of the marine production, Atlantic Ocean areas contributed 43.5 percent, and the Indian Ocean accounted for 5.2 percent. The United States again ranked fifth in fishery products with 4 percent of the world's production (Japan again led with 15.1 percent). About 70 percent of world fishery products were marketed fresh, frozen, cured, or canned. The remaining 30 percent were meal, oil, and miscellaneous products.

Volume 40 ($25.00) gives data on nominal catches of all fish, crustaceans, mollusks, aquatic animals, residues, and plants taken for commercial purposes from 1970 to 1975. The statistics are listed by country, continent, major fishing area, and by species group (freshwater fishes, diadromous fishes, marine fishes, crustaceans, mollusks, whales, seals and other aquatic mammals, miscellaneous aquatic animals, animal products, and invertebrates).

Volume 41 ($17.00) provides information on production and trade of fresh, chilled, frozen, dried, smoked, and salted fish, mollusks, and crustaceans. Production of each is given by country and product. The quantity and value of imports and exports are listed by country. Other commodities listed include crude and refined oils, animal feedstuffs, and meals and solubles of aquatic animal origin. Disposition of items produced from fish farming, shellfish culture, seaweed harvest, factoryships, etc. are also given.

Both volumes, printed in English, French, and Spanish, are available from UNIPUB Box 433, Murray Hill Station, New York, NY 10016.

Puget Sound Tidal Movements Charted

"Tide Prints: Surface Tidal Currents in Puget Sound," by Noel McGary and John W. Lincoln, is a detailed atlas with 32 charts showing simulated flow patterns of the Washington State Sound's surface currents at eight stages during a representative tidal day.

To get the data, a dark dye was injected into the waters of the University of Washington's Department of Oceanography's hydraulic model of Puget Sound. Then, the surface was dusted with polystyrene particles, the model's tidal mechanism was set in motion, and "aerial" photos of the effect was taken. The resulting photomosaics were then translated into the booklet's charts. The 48-page booklet was published by the Washington Sea Grant Program and is distributed by the University of Washington Press, Seattle, WA 98105. It costs $4.95.

Mid-Atlantic Continental Shelf Symposia Printed

Publication of the Special Symposia, Volume 2, Middle Atlantic Continental Shelf and the New York Bight, (viii, 441 pp.), M. Grant Gross, editor, has been announced by The American Society of Limnology and Oceanography, Inc. The symposium considered the environmental quality of the middle Atlantic continental shelf and New York Bight and assessed man's impact on this continental shelf ecosystem.

The volume is divided into nine sections: overview, physical processes, geological processes, waste sources and effects, the ecosystem and productivity, fish and fisheries, benthic processes, shellfish and fisheries, and public health. The volume is available (price not listed) from society treasurer A. M. Beeton, Department of Atmospheric and Oceanic Science, The University of Michigan, 2455 Hayward, Ann Arbor, MI 48109.

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